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**COVER:** A White-tailed Deer (*Odocoileus virginianus*) browsing on vegetation beside *Spiranthes casei* plants on a sandstone barrens of the Stony Swamp Conservation Area, Ottawa, Ontario. Photographed 30 August 2008 by Joyce M. Reddoch. See article Phenology, population dynamics, and flowering dynamics of Case's Ladies'-tresses, *Spiranthes casei* var. *casei*, (Orchidaceae) in Ottawa, Ontario, by Joyce M. Reddoch and Allan H. Reddoch pages 19-31.



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## THE OTTAWA FIELD-NATURALISTS' CLUB

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## Records of Recovering American Marten, *Martes americana*, in New Hampshire

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Kelly, Jillian R., Todd K. Fuller, and John J. Kanter. 2009. Records of recovering American Marten, *Martes americana*, in New Hampshire. *Canadian Field-Naturalist* 123(1): 1-6.

Recent and current distribution of state-threatened American Marten (*Martes americana*) in New Hampshire was identified by summarizing 157 occurrence records (1980–2004) in a database and mapped using Geographic Information Systems (GIS). Records included visual observations, snow tracks, road kill, trapper captures, systematic live-trapping locations, and other miscellaneous locations. Marten in New Hampshire are now found throughout the White Mountains north to the Canadian border, with the highest relative abundance in the very northern tip of New Hampshire. The recent expansion in the range of Martens includes reproducing females, but a sex ratio biased towards males in some areas suggests that dispersing individuals might inhabit much of the range.

**Key Words:** American Marten, *Martes americana*, distribution, New Hampshire.

Historically, American Marten (*Martes americana*) populations were distributed throughout the forests of eastern North America (Seton 1929), but excessive trapping and habitat loss during the late 19<sup>th</sup> and early 20<sup>th</sup> centuries resulted in regional population extirpations (Gibilisco 1994). Marten in many areas recolonized naturally, some recolonized through translocations, and others remain extirpated (Powell et al. 2003). For example, Marten populations have recovered and are trapped under protective regulations for their valuable fur throughout Maine, Quebec, northern New Brunswick, and the Adirondacks of New York (Ray 2000\*). Yet in places in the Northeast, such as New Hampshire, Vermont, and Nova Scotia, Marten populations are protected and have remained scarce or even absent, despite reintroduction attempts that have had varied success (Slough 1994; Ray 2000\*; Moruzzi et al. 2003). At their distributional edge, such as in Maine, New Hampshire and Vermont, unstable populations are often a result of habitat alteration and fragmentation of forested environments (Gibilisco 1994; Kelly 2005). Monitoring the distribution of Marten in these areas can provide insight into the extent and degree of habitat alteration and fragmentation effects not only for Marten, but for a variety of other forest-dependent wildlife species, as well.

American Marten in New Hampshire were considered “quite common in Colonial times except along

the sea coast” (Silver 1957\*). Historical records indicate Marten were traded as far south as Bedford (present day Manchester), in Hillsborough County in 1754 (Figure 1). Yet virtually all information concerning the distribution of Marten before extensive land clearing comes from Coos County (Figure 1), where Marten were routinely trapped through the first third of the 20<sup>th</sup> century (Silver 1957\*).

During the early 1900s, New Hampshire’s American Marten population declined dramatically, most likely due to the cumulative effects of unregulated trapping, the conversion of forest to farmland, and the rapid deforestation of the landscape due to logging (Silver 1957\*). In an attempt to protect the remaining population, the New Hampshire legislature eliminated Marten trapping statewide in 1935 (Silver 1957\*).

Marten continued to remain scarce through the 1970s, despite two reintroduction attempts. The first occurred in 1953 when two Marten (one male, one female) from Ontario were released in The Second College Grant in northeast New Hampshire (Silver 1957\*; Figure 1). There were no surveys or other attempts to evaluate the success or failure of this reintroduction. Then in 1975 the United States Forest Service (USFS) attempted a second reintroduction. Twenty-nine Marten (20 males, 9 females) were acquired from Piscataquis County, Maine, and released on the west side of the Wild River in Shelburne, New



Hampshire (Figure 1; Soutiere and Coulter 1975\*). At this time no Marten were thought to exist along the eastern border of New Hampshire or in the bordering area of Maine (J. Lanier, New Hampshire Fish and Game, personal communication). The result of this reintroduction is also unknown due to the limited amount of follow-up information collected on the released Marten (J. Lanier, personal communication).

Before 1979, reports of Marten sightings or sign were very uncommon in New Hampshire. As a result, American Marten were one of the first species added to the state's newly adopted (1979) State Endangered Species Conservation Act (RSA 212-A). Since the early 1980s, evidence of Marten presence has been observed in towns throughout northern New Hampshire (W. Staats, New Hampshire Fish and Game, personal communication). Moreover, within the last 20 years, based on tracks and sightings, the northeastern border of New Hampshire has been an epicenter of Marten activity. Since the early 1990s, biologists have conducted searches for Marten sign during the winter as time permitted (W. Staats, personal communication). Despite these efforts, Marten population status and distribution in New Hampshire remain poorly understood. As a result, the objective of this study was to identify recent occurrence, distribution, relative abundance, and status of Martens in New Hampshire.

## Study Area

Marten occurrence and general distribution were assessed throughout New Hampshire (24217 km<sup>2</sup>; Figure 1). Statewide, there are large latitudinal and elevational gradients which provide a wide variety of natural communities, including boreal forest in the north and coastal dunes in the southeast (DeGraaf and Yamasaki 2001). Mount Washington, the tallest peak in New Hampshire and the Northeast at 1915 m, is located near the center of the northern half of the state and is surrounded by numerous other peaks >1000 m (Figure 1).

The overall climate of the northern half of the state, our focal study area, is best characterized by warm, wet summers and cold, snowy winters. The mean annual precipitation is 910–1780 mm and the total annual snowfall ranges from 2440 to 4060 mm; both of which increase locally with elevation (McNab and Avers 1994\*). The mean annual temperature varies between 3 and 7°C (McNab and Avers 1994\*).

New Hampshire is about 86% forested. Low-lying valleys are covered by deciduous forests consisting of Sugar Maple (*Acer saccharum*), Yellow Birch (*Betula alleghaniensis*), and American Beech (*Fagus grandifolia*), with Eastern Hemlock (*Tsuga canadensis*) scattered throughout. Lower elevation mountain slopes and low lying valleys can also consist of a mix of spruce (*Picea* spp.), fir (*Abies* spp.), maple, beech (*Fagus* spp.), and birch (*Betula* spp.). At higher elevations pure stands of Balsam Fir (*Abies balsamea*) and Red Spruce (*Picea*

*rubens*) are most common. Krummholz, defined as stunted deciduous or coniferous vegetation that occurs just below tree line, is often found at the highest elevations.

Disturbance, specifically logging and the conversion of forest to agricultural land, has dramatically affected the forest composition throughout New Hampshire. Agriculture seems to have had the greatest impact on forested landscapes by changing the cover type and soil structure over a wide range of sites (DeGraaf and Yamasaki 2001). Even today, the forests of New Hampshire show signs of being highly affected by historic and current logging, especially of conifers (McNab and Avers 1994\*). This is especially evident in northern New Hampshire, where >90% of the area is forested and the landscape remains in large private ownerships which are actively managed for high timber production.

## Methods

Distribution data were collected and compiled into a single database to create a known point-distribution map for Marten in New Hampshire. The five primary sources of data and their selection criteria were:

(1) Recent Marten observational data (1980–2000 – New Hampshire Fish and Game Department occurrence data) were compiled from “screened” (i.e., observations that could not be verified from verbal descriptions were not included) sighting and observation records obtained from the state furbearer biologist.

(2) Current observational data (2000–2004) – observations and track identification locations from state and federal natural resource agencies, as well as unpublished field notes and observations from agency biologists, fur trappers, and foresters, and information received from screened observations from the public. Since 2000, a special effort has been made to encourage reports of Martens in New Hampshire to be recorded and passed on to the New Hampshire Fish and Game Department. Occurrence records such as track identification were only included if the tracking ability of the observer had been assessed and the ability to identify Marten tracks had been confirmed by a biologist or conservation officer, or sufficient evidence of Marten sign was presented.

(3) Recent and current incidental captures by fur trappers during the trapping season – Information was collected from post-capture trapper interviews, including the set type used when a Marten was incidentally captured, any evidence of ear tags, and the exact location of kill or capture.

(4) Recent and current road kills – collected from Marten recovered by New Hampshire Fish and Game staff, and

(5) Live-trapping data – collected during summer 2003 and 2004 throughout the Connecticut Lakes and Mahoosuc-Rangeley ecological subsections (Figure 2), as defined by Keys et al. (1995\*). Live-traps were placed



on a home-range-sized grid (Raphael 1994; Gese 2001) over a reclassified cover type map that had been stratified to sample deciduous, coniferous, and mixed deciduous coniferous cover types equally (Kelly 2005). To maximize the number of cells that could be sampled, traps were all placed along roads that were within randomly selected cells. Specific trapping locations were selected based on natural topographic features such as elevation gradients and proximity to water. Two traps were placed at each sampling location to maximize the opportunity of capturing a Marten. The protocol for capturing and marking Martens was reviewed and approved by the University of Massachusetts at Amherst Institutional Animal Care and Use Committee (Protocol #24-02-02).

From the collected occurrence data and live-trapping captures, a known point-distribution database was then created in Microsoft Access (Microsoft Inc., Seattle, Washington). The majority of records for this study occurred in the three most northern subsections within the White Mountain Ecological Section: Connecticut Lakes, Mahoosuc-Rangeley, and White Mountain (Keys et al. 1995\*; Figure 2). All records were mapped as latitude, longitude points to the nearest second. The majority of the recent points (before 2000), were derived from hand drawn maps, with  $\leq 152$ -m accuracy. Current points (collected after 2000) were mapped at much finer resolutions ( $\geq 12$ -m accuracy).

Recorded historical Marten captures and occurrences that could not be verified, or did not have specific locations identified, were excluded from the database. Therefore, the results presented herein are a sample ( $>85\%$ ) of identified records and should not be considered an inventory of all Marten records statewide.

Population structure variables were recorded for each ecological subsection where Marten were documented; these include age (juveniles and subadults/adults) and sex ratios, and evidence of breeding indicating local resident populations (Strickland et al. 1982). Tooth sectioning and aging from cementum annuli were conducted commercially (Matson's Lab, Milltown, Montana). Age categories included juveniles ( $<1$  years old), non-breeding sub-adults (1–2 years old), and adults ( $>2$  years old).

Catch per Unit Effort (CPUE) was calculated as the number of individuals per 100 trap-nights, a trap-night being equal to one trap set for 1 night, assuming that each trap night was an independent event (i.e., 10 trap-nights = 10 traps set for 1 night = 1 trap set for 10 nights). Traps that were closed during the night or were occupied by non-target species were counted as 0.5 trap nights. To assess CPUE, a constant effort model was used to estimate population abundance (Lancia et al. 1996).

## Results

The distribution information collected from 1980–2004 resulted in about 180 records, of which 157 (87%)

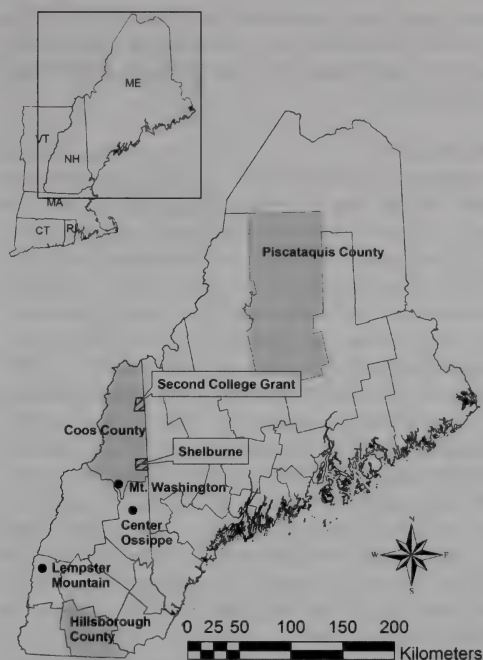


FIGURE 1. Location of various sites in Maine and New Hampshire identified in the text.

were considered reliable documentation of Marten occurrence in New Hampshire (Figure 2). These included 22 visual observations, 57 records of snow tracks, 2 roadkills, 37 trapper captures, 37 live-captures, and 2 miscellaneous reports. The Connecticut Lakes ecological subsection contained 57% of the collected records whereas the Mahoosuc-Rangeley and White Mountains ecological subsections contained 27% and 16%, respectively. Furthermore, 10% of the occurrence records were made before 1999, whereas 90% were documented after 2000.

Total live-trapping effort for Marten in the Connecticut Lakes and Mahoosuc-Rangeley subsection was 4095 trap nights. In the Connecticut Lakes subsection 86 individual locations were sampled using 172 traps whereas in the Mahoosuc-Rangeley subsection 91 individual locations were sampled using 182 traps. Catch per unit effort (captures/100 trap-nights) for live-trapped Marten in the Connecticut Lakes and Mahoosuc-Rangeley subsections was 2.03 (34 captures) and 0.14 (3 captures), respectively, and 1.05 overall.

Of the 76 killed or live-captured Marten noted above, we could assess age for 47. Most of these (41) were males, including 10 juveniles ( $<1.0$  yr), 13 sub-adults, and 24 adults ( $\geq 2.5$  yr). Of the six aged, female Martens, three were juveniles (all captured in the Connecticut Lakes ecological subsection), and three were adults ( $\geq 2.5$  yr), two of which were live-trapped in the

Connecticut Lakes subsection and were confirmed to be breeding according to age, and the presence of enlarged or crusted teats, or expressed milk (Fuller and Harrison 2005).

## Discussion

Although anecdotal reports from as far south as Center Ossipe and Lempster Mountain in Sullivan County (Figure 1) could not be confirmed due to the lack of verifiable information, our occurrence data suggest important temporal and spatial trends in Marten occurrence in New Hampshire. First, many more incidental reports (not our systematic live-trapping) were reported during the 5 years of 2000-2004 ( $n = 105$ ) than in the previous 20 years ( $n = 15$ ); this could suggest that the Marten population is expanding numerically, but as noted above, a special effort was made to encourage reports of Martens in New Hampshire after 2000. Second, the distribution of Martens is likely uneven, with more occurring in the Connecticut Lakes (CL) region than in the Mahosuc-Rangeley (MR), as indicated by our systematic live-trapping/CPUE ( $>14$  times more in CL than MR), and from observational or incidental trapper capture records ( $n = 56$  for CL vs. 25 for MR). We recognize that the documentation of Marten distribution based solely on the results of observations (i.e., reports from the public or directed searches) could be biased, but they do match the trend in results of our systematic live-trapping/CPUE surveys. In addition, we note that many occurrences were also documented in the White Mountains subsection where we did not live-trap due to time and access constraints, but where it seems likely that Marten occur in some numbers (39 records).

In most of the past half century, Marten in New Hampshire were considered scarce, if not extirpated, despite a ban on trapping in 1953 and several reintroduction attempts. Potential factors leading to the slow recolonization of New Hampshire by Marten, and their rapid increase recently, include (1) depressed initial population size and limited source populations, (2) delays in forest maturation, (3) changes in carnivore communities, and (4) climate change (cf. Carroll 2007).

Sixty years ago, Marten populations in states adjacent to New Hampshire also were low. By 1941 Marten in Maine were considered extremely rare and were restricted to the northern and northwestern areas of the state (Aldous and Mendall 1941\*). Yet, over time and with a state-sponsored Marten-transplant program in the early 1980s (W. Jakubas, Maine Division of Inland Fisheries and Wildlife, personal communication) Marten in Maine increased in number throughout the mid-1900s and expanded into western and eastern Maine (Silver 1957\*). In 1985, the Marten population in western Maine (bordering New Hampshire) may have numbered 624, or 6.1/100 km<sup>2</sup> (W. Jakubas, personal communication), and likely served as the primary source for recolonization of northern New Hampshire. Marten

populations to the north of New Hampshire in Canada (Figure 1) are also considered moderate to low (H. Jolicoeur, Quebec Ministry of Natural Resources, personal communication), and an abundance of adjacent agricultural land likely limits Marten dispersal to northern New Hampshire.

Forest fragmentation and change in composition may affect Marten population viability (Carroll 2007), and during the late 1800s and early 1900s timber harvesting concentrating on softwood for pulp was extensive in New Hampshire. Extensive salvage harvesting of deciduous and coniferous stands also resulted from the hurricanes of 1938 and 1950, as well as the spruce budworm outbreak of 1973. As a result, historic coniferous stands regenerated to deciduous cover due to the lack of established coniferous regeneration. Coniferous and mixed wood cover can be very important to Marten in eastern North America, especially during winter months (Raine 1983; Buskirk et al. 1988; Fuller and Harrison 2005; Gosse et al. 2005), and in combination with low numbers, Marten population expansion may have stalled. Over the past 40 years, however, large blocks of forest have been conserved and are being managed to better provide for a variety of wildlife species including Marten.

Another potential factor contributing to the slow recolonization of New Hampshire by Marten would be an overall change in the carnivore communities. Fishers (*Martes pennanti*) have been identified as a potential limiting factor for Marten (Krohn et al. 1995; Kelly 2005). As Fisher populations in New England have expanded into highly disturbed (developed) habitats (Ray 2000\*), there may be competition limiting further Marten dispersal and colonization.

Lastly, climate change, which has resulted in decreased snow depths in winter, may be pushing Marten further north and into higher elevation habitats with more snow (Kelly 2005). Marten have specific morphologic features such as relatively large feet compared to their overall body size and weight (Raine 1983), which gives them an advantage in areas with deep snow. It is suspected that Fisher populations may be more limited than Marten in areas with deep snow, because they are less adapted to such conditions (Krohn et al. 1995). Changes in snow depth and distribution over the past 100 years have been well documented in New Hampshire and may influence Marten distribution (Carroll 2007).

The limited data we collected on Marten reproduction and age structure suggest that population recovery is occurring, albeit perhaps somewhat slowly. Reproductively active females and occurrence of juvenile animals indicate successful reproduction (Strickland and Douglas 1987; Buskirk and Ruggiero 1994; Powell et al. 2003), and a good number of sub-adults suggests that juveniles are surviving and/or immigration and dispersal from adjacent populations (Thompson 1994) are occurring, as well. Male Marten and other



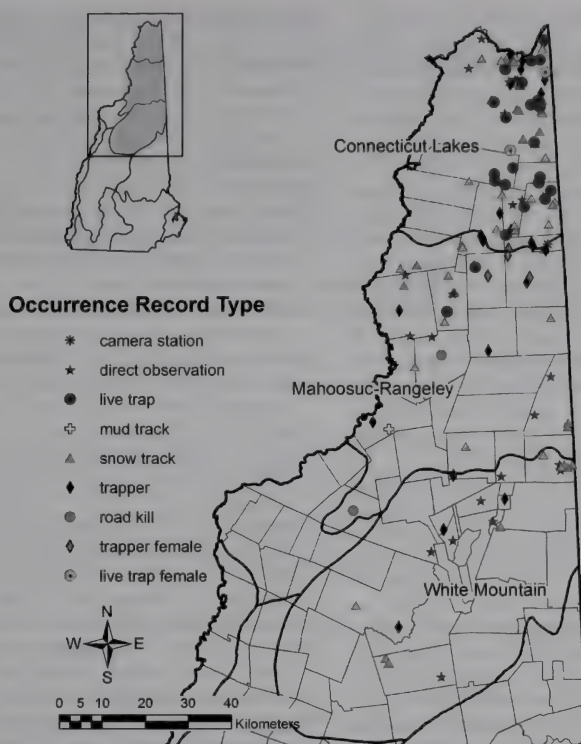


FIGURE 2. Overall distribution of confirmed marten observation/occurrence records relative to ecological subsections (Keys et al. 1995\*) in New Hampshire (1980-2004).

mustelids are, in general, more easily trapped than are females (Martens – 52-62% males; Buskirk and Lindstedt 1989), but the lopsided proportions we found (87% of 47) are difficult to interpret because sex ratios of unharvested Marten populations are difficult to determine, especially when only a small sample of the total population is available (Powell 1994).

Although Marten recovery cannot be confirmed based solely on our findings, a better understanding of distribution allows managers to identify goals and objectives to further Marten recovery in New Hampshire. Consideration of historical and current land use practices will be extremely important as land use values change throughout the primary distribution of Marten in New Hampshire.

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# West Nile Virus as a Cause of Death Among Endangered Eastern Loggerhead Shrikes, *Lanius ludovicianus migrans*, in West St. Paul, Manitoba

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In July 2006, three Eastern Loggerhead Shrike (*Lanius ludovicianus migrans*) nestlings were found dead in a nest in West St. Paul, near Winnipeg, Manitoba. The Eastern Loggerhead Shrike is an endangered form in Canada and populations are in decline. Reverse transcription-polymerase chain reaction and immunohistochemical staining detected West Nile virus in the tissues of the nestlings indicating the cause of death. This is the first confirmed report of West Nile virus in wild populations of Eastern Loggerhead Shrikes in North America. These findings will challenge conservation biologists in their efforts to develop recovery and management plans for the endangered Eastern Loggerhead Shrike, as well as in the implementation of captive rearing programs.

Key Words: West Nile virus, Eastern Loggerhead Shrike, *Lanius ludovicianus migrans*, endangered species, immunohistochemistry, RT-PCR, flavivirus.

West Nile Virus (*Flavivirus*: Flaviviridae) was first discovered in North America in New York City in 1999 and has since spread across much of the continent (Lanciotti et al. 1999; Drebot et al. 2003; Bertelsen et al. 2004; Nash et al. 2006). Birds are the principal amplification hosts of West Nile Virus and *Culex* mosquitoes are recognized as the major vector (Rappole et al. 2000; Lanciotti et al. 2000; Drebot et al. 2003; McLean 2006). North American data revealed that about 48 000 birds [predominantly American Crows (*Corvus brachyrhynchos*) and Blue Jays (*Cyanocitta cristata*)] belonging to about 300 species have been reported infected with West Nile Virus in the North America alone (McLean 2006). The Eastern Loggerhead Shrike (*Lanius ludovicianus migrans*) is a subspecies of grassland songbird found in North America. West Nile Virus has previously been found in a population of captive Eastern Loggerhead Shrikes in Ontario, where five Eastern Loggerhead Shrikes died in 2002, at the Toronto Zoo's captive breeding facility (Bertelsen et al. 2004). West Nile Virus was confirmed in all organs examined using immunohistochemistry, and its viral genome was amplified from brain and kidney samples using reverse transcription (RT) -polymerase chain reaction (PCR) (Bertelsen et al. 2004).

The wild Loggerhead Shrike (*Lanius ludovicianus*) population has experienced persistent declines across its North American range since 1966 (Pruitt 2000\*). These declines have been most significant in the range of the Eastern Loggerhead Shrike, a subspecies found

in the northeastern and mideastern United States and in eastern Canada (Pruitt 2000\*). The Eastern Loggerhead Shrike has been considered endangered in Canada since 1991 and was officially listed as endangered under the federal *Species at Risk Act* in 2003 (Wildlife Preservation Canada 2005\*; Environment Canada 2006\*).

In Canada, the Eastern Loggerhead Shrike is extirpated from Quebec as well as the Maritime provinces. Sharp population declines have been observed in remaining pockets of suitable habitat in Ontario and Manitoba (Government of Canada 2008\*). In 2004, surveys revealed 36 known breeding pairs in Canada (Wildlife Preservation Canada 2005\*). Subsequent surveys revealed further declines in wild populations to 20 pairs in 2005, and to 22 pairs in 2006 (Wildlife Preservation Canada 2005\*; Lindgren 2006\*). In Manitoba, numbers declined from 11 known breeding pairs in 2000 to five pairs in 2006 (Lindgren 2006\*). It has yet to be determined why Loggerhead Shrike populations are in decline, and hence, there is an urgent need to better understand limiting factors that may be contributing to these declines. Although suitable habitat for Eastern Loggerhead Shrikes appears to exist in several areas throughout Manitoba, its population continues to decline.

West Nile Virus was first detected in birds in Manitoba on 15 July 2002 (Preston 2002; Drebot et al. 2003). A literature search found no reports of West Nile Virus infecting Eastern Loggerhead Shrikes in Mani-

toba or in any other wild populations across its range although diseases were involved in the deaths of at least two captive Eastern Loggerhead Shrikes (Pruitt 2000<sup>\*</sup>). This paper represents the first report of West Nile Virus causing death in wild Eastern Loggerhead Shrikes providing documentation of a natural West Nile Virus infection in a new susceptible bird species, contributing to the information on the natural history, spatial distribution, epizootiology, and virus-vector-host relationship of the disease.

## Methods

Since 2000, Eastern Loggerhead Shrike nesting activity in southeastern Manitoba has been monitored in three core breeding areas immediately north and west of Winnipeg where the birds annually return to nest. These core areas are the suburban municipalities of West St. Paul (49°58'N, 97°4'W), Rosser (49°59'N, 97°26'W), and Headingly (49°52'N, 97°24'W). Annual surveys for Eastern Loggerhead Shrikes involve searches for returning birds at nesting sites from previous years and in other suitable habitats near the city of Winnipeg. Nests, once located, are followed up through regular nest checks to determine parents, final clutch size, and the number of young that hatch and survive to fledging age.

Three dead nestlings were discovered in their nest during a routine check and a complete necropsy was conducted on all three. Overall findings were very similar in all three cases and were therefore combined into a single case report. Various tissues were collected for analysis in bacteriology and virology. Representative samples of the major organs were also processed for histopathology and stained with hematoxylin and eosin (Bertelsen et al. 2004). Frozen brain, heart, and kidney samples were analyzed for the presence of West Nile Virus ribonucleic acid (RNA) by RT-PCR (Lanciotti et al. 2000; Drebot et al. 2003). In brief, 5 mm<sup>3</sup> pieces of frozen tissue were placed in microtubes (safe-seal tubes with lid, Sarstedt, St-Leonard, Quebec) containing 1.5 mL of RLT lysis buffer (RNeasy mini kit, Qiagen, Mississauga, Ontario), 0.1 M 2-mercaptoethanol (Fisher Scientific, Whitby, Ontario), 0.4% (w/v) sarkosyl detergent (Sigma-Aldrich, Oakville, Ontario) and either one (for brain) or three (for heart and kidney) 1/8 inch stainless steel ball bearings (BC-Bearing, Winnipeg, Manitoba). The microtubes were placed in balanced pairs on chilled 24-place racks (TissueLysar Adapter Set, Qiagen, Mississauga, Ontario) and shaken for 3 minutes at 25 Hz using a Mixer Mill homogenizer (model 300, Retsch, Newton, Pennsylvania, USA). Ribonucleic acid was extracted from the homogenate, eluted in nuclease-free Tris-EDTA buffer (pH 8.0; Ambion/ Applied Biosystems, Streetsville, Ontario), and stored until used (Lanciotti et al. 2000).

An RT-PCR assay that amplifies a 238 base pair fragment of the non-structural protein 3 region of the West Nile Virus genome was then conducted using

the eluted RNA. The assay was performed with a one-step RT-PCR kit (Qiagen, Mississauga, Ontario) using 3 µL of RNA and 300 nm of each primer (i.e., NS3a and NS3d, Drebot, personal communication) in 25 µL reaction volumes. This was then overlaid with one drop of molecular biology grade light mineral oil (Sigma-Aldrich, Oakville, Ontario). Reactions were carried out in a programmable thermal cycler (MJ Research model PTC 100, Bio-Rad Laboratories, Mississauga, Ontario) using a modified "step down" thermocycling program with 57 cycles of amplification (Hecker and Roux 1996). After thermocycling, 3 µL of gel loading solution (50% sucrose, 2 mM EDTA, 0.1% bromophenol blue, 0.1% xylene cyanole; pH 8.0) was mixed into each reaction, and a 13 µL fraction was analyzed by electrophoresis in a composite agarose-acrylamide gel (Visigel, Stratagene, La Jolla, California, USA) containing 0.15 µg/mL ethidium bromide. After electrophoresis, the gels were visualized on a UV transilluminator (Fisher Scientific, Whitby, Ontario) and photographed using a Polaroid gel camera (Fisher Scientific, Whitby, Ontario).

To support the RT-PCR results and confirm that West Nile Virus was present in the actual cells of the tissues, as there were minimal histological lesions, paraffin blocks of brain, heart, and kidney were submitted to the Immunology Laboratory of Prairie Diagnostic Services (Saskatoon, Saskatchewan). Immunohistochemical staining was conducted using a technique adapted for an automated slide stainer (Code-On Histomatic Stainer, Fisher Scientific, Edmonton, Alberta) (Haines and Chelack 1991), with a 1:1000 and 1:2000 dilution of rabbit anti-West Nile Virus antibody (BioReliance Corp., Rockville, Maryland, USA). Binding of the primary antibody was detected using goat anti-mouse and anti-rabbit immunoglobulins conjugated to peroxidase-labelled polymers (EnVision + Dual Link, Dako Canada Inc., Mississauga, Ontario).

## Results

Surveys during April through July 2006 revealed at least five nesting Eastern Loggerhead Shrike pairs in the core areas near Winnipeg. Only one of these pairs was located in West St. Paul, at a site that been successful every year since 2001 and had produced a successful second clutch in 2003. On 13 May 2006, the West St. Paul nest was observed with a completed clutch of five eggs. Four of the eggs hatched and the young were banded on 6 June 2006. They fledged a few days later and were observed with the adults in various locations throughout the nesting territory for at least the next month. In late June, the pair began to build a second nest in a Siberian Elm (*Ulmus pumila*) tree about 200 meters from the original nest site. On 4 July 2006, the nest contained a complete clutch of four eggs. By 13 July 2006, three young had hatched. On 20 July 2006, the young had reached ideal banding age (i.e., seven to ten days old) and were banded.



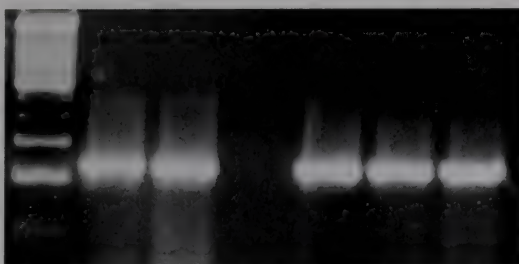


FIGURE 1. Photomicrograph of an ethidium-bromide-stained agarose gel of polymerase chain reaction products obtained with use of a West Nile Virus primer set. From left to right, the far left lane is a 100-base-pair (bp) DNA ladder (Invitrogen). The next two lanes identified are amplified DNA from the positive control. The middle lane is a negative control (i.e., no DNA). The next three lanes represent DNA obtained from three Eastern Loggerhead Shrike nestlings. Each test consisted of pooled avian heart, brain, and kidney tissue from an individual nestling.

The approximately two-week old nestlings appeared healthy when observed on 26 July 2006, but were found dead in the nest on 29 July 2006. The dead young appeared undisturbed and there was no evidence that they had struggled. The circumstances surrounding the deaths were considered unusual and the young were immediately collected and frozen for later analysis.

Gross post-mortem findings following necropsy of the nestlings were non-specific, with evidence of dehydration in that the eyes were sunken and the skin was difficult to remove. A few bones, hair, and plant stalks were found in the ventriculus, but otherwise the digestive tract was completely void of contents. The liver and lungs appeared to be congested. No other significant abnormalities were observed and there was no evidence of any trauma.

Analysis in bacteriology and virology revealed no significant bacteriological organisms or intestinal parasites, allowing for the elimination of the possibility of septicemia. Polymerase chain reaction (PCR) results for brain, kidney, heart, and lung tissue returned negative for both Newcastle Disease and Influenza-A matrix. Histopathology and staining analysis revealed lymphoid depletion and necrosis were evident within scattered follicles of the bursa of one bird and rare blood vessels in the lungs and glomeruli contained fibrin thrombin. No other significant abnormalities were observed. Immunohistochemical staining results were positive for West Nile Virus antigen in all tissues submitted (Figure 1).

## Discussion

With strong West Nile Virus genome amplification and positive staining for West Nile Virus antigen in the bird tissue, along with high *Culex tarsalis* counts in the region, it was concluded that West Nile Virus was the acute cause of death in all three Eastern Log-

gerhead Shrike nestlings. This is the first confirmed report of West Nile Virus killing wild Eastern Loggerhead Shrikes in North America. Our results are significant for conservation biologists, as it has implications for recovery and management plans for the subspecies, and therefore West Nile Virus must be considered as a significant limiting factor for Eastern Loggerhead Shrikes. The breeding behaviour of the Eastern Loggerhead Shrike also makes it more susceptible to the virus. Loggerhead Shrikes aggregate their breeding territories and these aggregations result in the attraction of conspecifics (Cade and Woods 1997). These aggregations of nesting shrikes would make populations particularly vulnerable to disease outbreaks such as the West Nile Virus outbreak in New York City in 1999 where large numbers of dead or dying birds were observed concurrently with clinical reports of human infection (McLean 2006) and die-offs of captive birds at the Bronx Zoo (Rappole et al. 2000; Steele et al. 2000). Our results also have implications for captive rearing programs. The release of young birds should not occur in areas suspected to have West Nile Virus or areas that have large populations of the *C. tarsalis* mosquito. Also, careful consideration as to where captive rearing facilities are placed in the environment is needed with respect to potential or historical West Nile Virus zones. Conservation biologists may want to consider setting out mosquito traps to assess mosquito populations prior to releases of captive reared Eastern Loggerhead Shrikes. Further, captive rearing programs should consider vaccination programs prior to release of shrikes into the wild. For example, this technique has been proven effective in the past where the highly endangered California Condor (*Gymnogyps californianus*) was successfully vaccinated both in captivity and in the wild, stimulating protective immunity in adults, nestlings and newly hatched chicks (Chang et al. 2007).

For the Eastern Loggerhead Shrike, the impacts of West Nile Virus may be more severe as these birds exist in small, isolated populations that are already threatened by habitat loss (Naugle et al. 2004). This has already been shown for the endangered Greater Sage-Grouse (*Centrocercus urophasianus*), whose population is under similar circumstances, an endangered species in Canada which is susceptible to West Nile Virus (Clark et al. 2006). Fieldwork has indicated that West Nile Virus has resulted in a 25% decline in survival in Greater Sage-Grouse in Alberta, Wyoming and Montana (Naugle et al. 2004; Walker et al. 2004).

West Nile Virus infection rates are higher in nestlings than in adult birds and nestlings may also be more susceptible to mosquito bites as they are physiologically incapable of avoiding mosquito attack (Austin et al. 2004). Further, second clutches of young Eastern Loggerhead Shrike may be more susceptible to West Nile Virus in Manitoba as they coincide temporally and spatially with the peak of the *C. tarsalis* popula-



tion levels (Figure 2). Mosquito surveillance data indicate that West Nile Virus peaks in southern Manitoba at the end of July and beginning of August, the precise time when the young Eastern Loggerhead Shrike in this case died (Manitoba Health 2006a\*). For example, an average high of 83 adult *C. tarsalis* (i.e., the species known to carry West Nile Virus) mosquitoes were caught per trap during the week of 23-29 July 2006 in the Winnipeg area (Manitoba Health 2006b\*). Further elevating the risk to the Eastern Loggerhead Shrike, large numbers of *C. tarsalis* mosquitoes have historically been attracted to the West St. Paul area, one of the core breeding areas for the Eastern Loggerhead Shrike. In July 2006 an order was issued under Manitoba's *Environment Act* to control the mosquitoes in this area as a significant number had become infected with West Nile Virus (Manitoba Health 2006b).

Our results also provide evidence of Eastern Loggerhead Shrike derived mosquito blood meals. Knowledge of vector host preferences is important in understanding West Nile Virus transmission cycles and identifying primary amplifying hosts (Lee et al. 2002; Ngo and Kramer 2003; Molaei and Andreadis 2006; Molaei et al. 2006). Polymerase chain reaction assays have been used to identify blood meals of mosquitoes finding feeding preferences for numerous avian species; however, no reports of blood meals derived from Eastern Loggerhead Shrikes (Lee et al. 2002; Ngo and Kramer 2003; Molaei and Andreadis 2006; Molaei et al. 2006).

Finally, potential impacts of West Nile Virus on the Manitoba Eastern Loggerhead Shrike are amplified as it is a unique defined population that has adapted to suburban areas. The preference for suburban areas also makes it more susceptible to West Nile Virus as nesting locations tend to be closer to marshes and wetlands. The Manitoba nesting population of Eastern Loggerhead Shrike has traditionally differed from the Ontario population in its preference for suburban, residential breeding habitats. Therefore, the Manitoba population may well represent unique genetic adaptations expressed in their preference for suburban regional environments. Ontario populations, on the other hand, are generally associated with active or idle pasture, grassland, or old field habitats (Chabot et al. 2001; COSEWIC 2004\*) and these habitats are being lost due to expanding urbanization and agricultural intensification. As these habitats are lost, the Ontario Eastern Loggerhead Shrike population may also be eventually lost. The Manitoba population then may be better adapted to sustain, and potentially increase, overall population numbers in light of its unique preference for suburban habitats. Acclimating urban shrikes to suburban environments remains a possibility (Cade and Woods 1997). In conclusion, the West Nile Virus presents a new challenge to the survival of the Eastern Loggerhead Shrike in Canada as well as to conservation biologists in species at risk recovery planning.

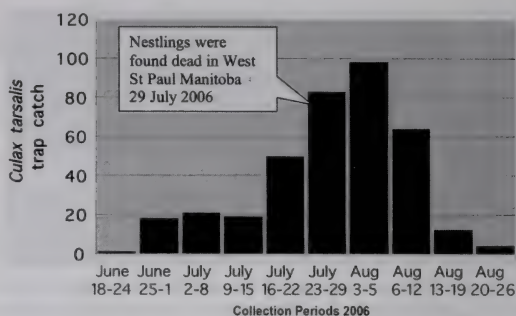


FIGURE 2. Average adult *Culex tarsalis* trap counts per week for the Winnipeg regional health authority area for 2006. Second clutches produced by Eastern Loggerhead Shrikes may be more susceptible to West Nile Virus as they coincide temporally and spatially with peak *C. tarsalis* population levels in the Winnipeg (Manitoba) area.

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# Terpenoid Resin Distribution in Conifer Needles with Implications for Red Tree Vole, *Arborimus longicaudus*, Foraging

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Tree voles are dietary specialists, feeding almost exclusively on conifer needles and bark. They reduce their exposure to conifer chemical defenses by physically removing resin ducts from many needles before ingesting the remaining tissue. The portion of needle removed differs among tree species, depending on the location of the resin ducts. To evaluate the amount of resin avoided by this behavior we removed the resin ducts from Douglas-fir, Western Hemlock, and Sitka Spruce needles and used gas chromatography to compare volatile resin concentrations in needles with and without the resin ducts removed. Needle tissues without resin ducts contained no terpenoid resin, demonstrating that tree voles can regulate the nutritional quality of their diet by controlling the amount of resin ingested. We suggest that differences in the physical structure (and possibly chemical composition of terpenes) of the needles make it difficult for voles to easily switch between tree hosts.

**Key Words:** Red Tree Vole, *Arborimus longicaudus*, terpenoid resins, resin ducts, plant-herbivore interactions, Oregon.

Foliar terpenoid resins of conifers are synthesized and stored in resin ducts. Like other plant secondary metabolites, they function as a chemical defense against pathogens and herbivores (Langenheim 2003; Stamp 2003; Dearing et al. 2005). Because these compounds are unpalatable, toxic, or impair metabolizable energy intake (Dearing et al. 2005; Iason 2005; Sorensen et al. 2005), there are relatively few mammals that live primarily on a diet of conifer needles. Notable exceptions include the Stephens' Woodrat (*Neotoma stephensi*) which feeds primarily on juniper foliage (Vaughan 1982), and the Woolly Flying Squirrel (*Eupetaurus cinereus*) in northern Pakistan which feeds primarily on pine needles (Zahler and Khan 2003).

The tree voles (Red Tree Vole, *Arborimus longicaudus*, Sonoma Tree Vole, *A. pomosus*) of western Oregon and northwestern California are also an exception in that they live in the canopy of coniferous trees and are dietary specialists, feeding almost exclusively on conifer needles and bark (Taylor 1915; Benson and Borell 1931; Hamilton 1962). Tree voles harvest their food at night, cutting off the tips of branches and transporting them back to the nest. Fresh cuttings are stored inside or on top of nests, thereby eliminating the need to forage during the day and allowing them to reduce their exposure to diurnal predators (Howell 1926). The cuttings are typically 2-30 cm long and consist primarily of needles from the current or previous year (E. Forsman, unpublished data). Tree voles obtain water from the internal water content of conifer needles and bark, and have also been observed in captivity to lick water droplets off needles and other surfaces (Clifton 1960; Maser 1998). In addition to being the only truly arboreal Microtine rodent, tree voles are an important food source for many small mammals and birds, in-

cluding weasels and owls (Forsman et al. 1984, 2004; Graham and Mires 2005; Swingle 2005). While they are primarily a resident of Douglas-fir (*Pseudotsuga menziesii*) forests, a small subset of the tree vole population in coastal northwest Oregon live and feed almost exclusively in forests of Western Hemlock (*Tsuga heterophylla*) and Sitka Spruce (*Picea sitchensis*) (Walker 1928, 1930; Clifton 1960). Occasionally they will utilize Grand fir (*Abies grandis*), Bishop Pine (*Pinus muricata*) or Monterey Pine (*Pinus radiata*) canopies for food and nesting sites, especially in California (Woster and Town 2002; Forsman and Swingle unpublished data, L. Diller personal communication).

One reason tree voles can exist on a diet of conifer needles is that they physically remove the resin ducts from many of the needles they consume, thereby regulating or reducing the amount of terpenoid resin ingested, and thus partially controlling the digestibility and nutritional quality of their diets (Howell 1926; Maser et al. 1981; Iason 2005; Iason and Villalba 2006). Douglas-fir needles contain two resin ducts near the outer margins (Figure 1). To remove them, tree voles bite off one needle at a time, hold it in their front feet and rapidly pass it sideways through the mouth, using their incisors to bite off a thin, longitudinal strip of tissue from the outer edge containing the resin duct. Then, they flip the needle over and repeat the process on the opposite edge. After removing both resin ducts, they eat the center portion of the needle (Howell 1926; Benson and Borell 1931). The average amount of time required for the entire process was 11.5 seconds for a vole we observed in captivity. The hair-like strands of tissue containing intact resin ducts are either discarded or used for nest material.



The feeding behavior of tree voles on Western Hemlock or Sitka spruce needles differs. Western hemlock needles have a single longitudinal resin duct running along the midrib (Figure 1), which the voles discard after eating the needle margins on both sides (Clifton 1960). Sitka Spruce has irregularly distributed, discontinuous resin ducts that are sometimes missing entirely or are concentrated in the basal half of the needle (Figure 1; Weng and Jackson 2000). We have limited observations of a captive vole that often browsed off the needle tips of Sitka Spruce, leaving the basal half where resin ducts are more common, uneaten. There are several cases in which we or others (Clifton 1960) have found small numbers of spruce resin ducts in vole nests, removed from the needle edges in the same way they are removed from Douglas-fir.

Although it is well known that tree voles reduce their exposure to terpenoid resins in conifer needles by physically removing the resin ducts where the terpenoids are concentrated, to our knowledge it is not known if this behavior allows them to avoid these compounds altogether, or only partially, if some portion of the volatile terpenes occur outside of the resin ducts. Herein, we describe a study in which we compared the resin content of whole needles to needles in which we surgically removed the resin ducts in a manner similar to the feeding behavior of tree voles. Our objective was to evaluate the effectiveness of resin duct removal in allowing voles to avoid ingestion of terpenoid resins in their diet.

## Methods and Materials

### *Plant Material*

Since some tree voles are known to spend their entire life in a single old growth tree (Swingle 2005), we sampled one tree of each species in the spring of 2006 in western Oregon. The trees sampled included a 56 cm dbh Douglas-fir 4.0 km northwest of Corvallis, Benton County (44.5820°N, 123.3474°W), and a 42 cm dbh Western Hemlock and 59 cm dbh Sitka spruce located 1.9 km north of Siletz, Lincoln County (44.7383°N, 123.9150°W). In each tree we collected 6 cuttings that were 30–50 cm long from the ends of different branches. Timing of collections was 10–14 April (Douglas-fir), 17–20 April (Western Hemlock), and 8–15 May (Sitka Spruce). The cut ends were wrapped with wet paper towels and transported to the laboratory, where they were shortened, if needed, to fit inside one gallon plastic bags. The open bags were stored in a dark 7°C coldroom with a wet paper towel around the cut end, and near the bag opening, to keep the needles moist. Current-year needles were removed from the branches and processed for analysis within 48–54 hrs of entering the coldroom, except for one pair of Sitka Spruce needles sampled at 72–78 hrs and another pair at 96–102 hrs.

### *Needle Sampling and Processing*

Needles were sampled the same way for all three conifers. We removed five needles in close proximity

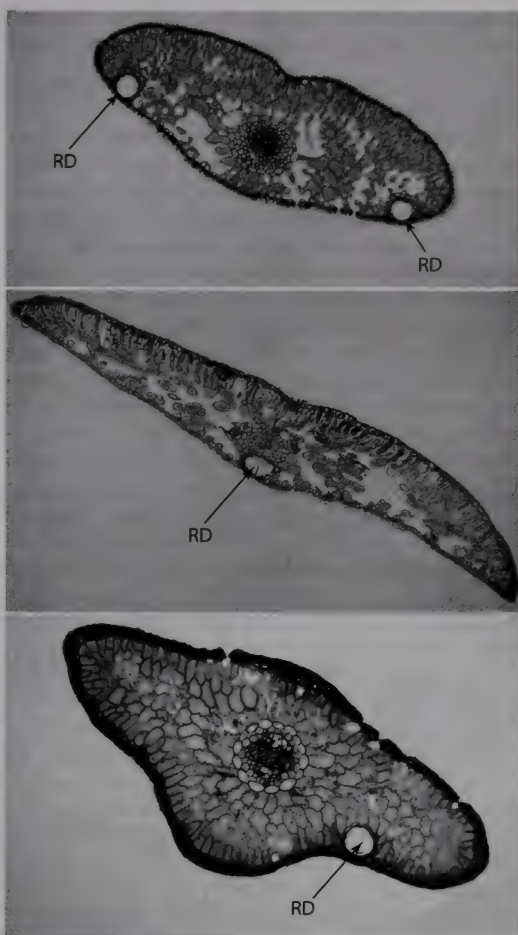


FIGURE 1. Photomicrographs of transverse cut conifer needles showing the location of resin ducts in Douglas-fir, top; Western Hemlock middle; and Sitka Spruce, bottom.

to one another from the branch cutting and randomly selected one of them for removal of the resin ducts. The remaining four were used to estimate needle water content by combining and weighing them in a small vial, then heating in a 102°C oven for 45–60 min to stop metabolic activity. The single needle then was weighed, cut, extracted, and analyzed as described below. When the analyses of all portions of the cut needle were complete, a second group of five needles was sampled from the same part of the branch as the first group. One was randomly selected for extraction without removing the resin ducts (i.e., whole) and the other four were used to estimate water content. When the gas chromatograph analysis of the whole needle extract was complete, this sampling scheme was repeated at another location on the same cutting, or on a different branch. When sampling was completed for the day, the needles selected for water content estimation were dried in the 102°C oven for 16 hrs, cooled in a desiccator box, and reweighed. Ten replicates of

dissected and whole needles were sampled from the six branch cuttings, with no more than two pairs from each branch.

#### *Needle Cutting and Extracting*

Douglas-fir needles, viewed in cross section, have an upper and lower surface, with a vascular cylinder down the midrib and a pair of longitudinal resin ducts along the outer edges of the needle (Figure 1; Apple et al. 2002). The resin ducts extend nearly the entire needle length. To remove the ducts, we taped the needle onto a dissecting microscope stage with the abaxial surface up and rows of white stomata clearly visible. Then, we used a single-edge razor blade to make longitudinal cuts on each side of the midrib following the mid to outside lines of stomata parallel to the leaf margins. This removed thin strips of tissue containing the resin ducts that were combined in a sealed 1.5 mL vial. The inner, midrib portion of the needle (without resin ducts) was placed in a separate, capped vial. Ethyl acetate (200  $\mu$ L, 99.9%) containing carvacrol (TCI America) as an internal standard was added to the tissue sample with resin ducts, and the tissue was crushed and cut with a sharp metal spatula for about 60 sec, then allowed to extract for 5 min. Two  $\mu$ L of this extract was injected immediately into the gas chromatography. When this analysis was complete, the vial containing the midrib portion of the needle was processed in the same manner. Then, another adjacent set of five needles was sampled and processed as above, except the whole single needle was crushed and extracted without removing the resin ducts.

In cross section, Western Hemlock needles have an upper and lower surface with a single resin duct that runs the length of the needle midrib, below the central vascular cylinder (Figure 1). To remove this duct, we taped each needle with the abaxial surface up and made a longitudinal cut along each side of the midrib with a single-edge razor blade. The midrib portion with the resin duct was placed in a vial and extracted and analyzed like the Douglas-fir, using 100  $\mu$ L of ethyl acetate containing carvacrol as an internal standard. The two strips of needle tissue from either side of the midrib were combined immediately in a sealed vial and further processed after analysis of the midrib tissue was complete.

Sitka spruce needles in cross-section have a shape similar to Douglas-fir, with a pair of resin ducts about midway between the midrib and the margins. However, the resin ducts of Sitka Spruce do not span the length of the needle; they are discontinuous and can be more like sacs, or may not be present at all (Figure 1; Weng and Jackson 2000). To help document this variability, the needle selected for cutting was partitioned into four quarters by first dividing it in half along the midrib. The right half of the needle was sealed in a vial and held for later processing. The left half then was cut at the longitudinal center to yield the apical

left and basal left quarters. These were sealed immediately in vials and the basal quarter held for extraction until the gas chromatography became available following analysis of the apical segment. When analysis of the left quarters was done, the right half of the needle was processed the same way. Because of their small size, these quarter needle segments were extracted with 50  $\mu$ L of ethyl acetate containing carvacrol as an internal standard, while the whole needle sample was extracted with 100  $\mu$ L of ethyl acetate containing carvacrol.

#### *Gas Chromatography*

We quantified volatile constituents in the extracts using a Hewlett Packard 5890 Series II gas chromatograph with a flame ionization detector and Phenomenex ZB-5 column (30 m  $\times$  0.25 mm  $\times$  0.25  $\mu$ m film thickness). Helium was the carrier gas, with a 1.0 mL/min flow through the column at 60°C and a 1:10 split. Injector and detector temperatures were 250°C. The oven program started at 60°C with a 5°C/min increase to 220°C with a 13 min final hold. Compound concentrations were calculated from the carvacrol internal standard using a 1:1 response factor, and expressed in  $\mu$ g/needle or needle segment and percent of needle dry weight.

Volatile compounds in the resins were identified by gas chromatography-mass spectrometry using the same instrument above with a 5970 mass selective detector (70 eV), and J&W Scientific DB-5 column (equivalent to the ZB-5 column above; 30 m  $\times$  0.25 mm  $\times$  0.25  $\mu$ m film thickness). Other operating conditions were as described. Each compound spectrum was verified with those in the Wiley library on the computer and with relative retention times and spectra reported by Adams (2007) for a DB-5 column. To get extracts with sufficient concentrations of resin for mass spectroscopy, we used a composite sample of needles from each species (10, 4, and 4 needles for Western Hemlock, Douglas-fir, and Sitka Spruce, respectively). The needles were cut into small pieces with a blade and extracted with 200  $\mu$ L of ethyl acetate. After soaking for 5.0 min, 2  $\mu$ L of the extract was immediately injected into the gas chromatography.

#### *Data Analysis*

Within each conifer species we used a *t*-test (Statgraphics® Plus Ver. 5.1) to compare the means of resin concentrations in whole needles to the dissected portions of needles that contained the resin ducts (sum of the four quarters for Sitka Spruce). Each data set was checked and found to be normally distributed with homogeneous variances. Needle portions without resin ducts contained zero resin, with no variance, and therefore was not compared statistically to needle portions with resin ducts, or to the whole needles. We used  $P \leq 0.05$  as the criterion for statistical significance.



TABLE 1. Resin concentrations and dry weights (mean  $\pm$  1 SE) for needles of three conifer species used as forage by Red Tree Voles (*Arborimus longicaudus*) in western Oregon. For each species, resin concentrations are provided for whole needles and for portions of individual needles with resin ducts (+RD), or without resin ducts (-RD)

Species/needle portion	Resin ( $\mu\text{g}/\text{needle}$ ) <sup>1</sup>	Whole needle dry wt ( $\mu\text{g}$ )	Resin (% dry wt)
Douglas-fir			
Margins (+RD)	45.68 $\pm$ 5.88 <sup>a</sup>		
Midrib (-RD)	0.00		
Whole needle	45.13 $\pm$ 6.14 <sup>a</sup>	5717 $\pm$ 285	0.77 $\pm$ 0.04
Western Hemlock			
Margins (-RD)	0.00		
Midrib (+RD)	39.00 $\pm$ 3.14 <sup>a</sup>		
Whole needle	39.81 $\pm$ 2.98 <sup>a</sup>	3511 $\pm$ 189	1.13 $\pm$ 0.03
Sitka Spruce			
Apex left quarter	0.00		
Apex right quarter	0.05 $\pm$ 0.05		
Base left quarter (+RD)	51.73 $\pm$ 11.21		
Base right quarter (+RD)	52.55 $\pm$ 10.15		
Sum all 4 quarters (+RD)	104.33 $\pm$ 20.91 <sup>a</sup>		
Whole needle	86.93 $\pm$ 12.69 <sup>a</sup>	6029 $\pm$ 173	1.60 $\pm$ 0.19

<sup>1</sup> Statistical analyses were done separately within each species. Concentrations within species followed by the same letter were not significantly different ( $P > 0.05$ ).

## Results

Resins in dissected needles of Douglas-fir and Western Hemlock were found only in those portions where resin ducts were located, and their total resin content was the same as measured by whole needle extraction (Table 1). Those portions of needles without resin ducts contained no terpenoids. In the Sitka Spruce samples, there was no resin in the apical half of the needles, except for one with a small amount ( $<1\%$ ; 0.46  $\mu\text{g}$ ) in the apical right quarter. This probably resulted from a slightly longer resin duct extending beyond the longitudinal mid-point. Mean concentrations of resins were the same in the Sitka Spruce basal left and right quarters, although there were two needles with extremely low amounts (1.66 and 0.43  $\mu\text{g}$ ) in the basal left side (Table 1). Sitka Spruce needles extracted whole had a slightly lower resin content than the total for needles cut into quarters, but the difference was not statistically significant. This difference was largely the result of one whole needle that contained almost no resin (0.07  $\mu\text{g}$ ).

Although our experiment was not designed to statistically compare characteristics among conifer species, our results do suggest that there are differences among species that could influence the vole's selection of host species. Douglas-fir and Western Hemlock had similar quantities of resin per needle, but the total resin content in Sitka Spruce needles was much higher than Douglas-fir or Western Hemlock (Table 1). Western Hemlock needles had a lower dry weight biomass than those of Douglas-fir or Sitka Spruce, which were about the same (Table 1). Douglas-fir had the lowest resin concentrations calculated as a percentage of the needle dry weight (0.77%), followed by Western Hemlock (1.13%), and Sitka Spruce (1.69%). The

Douglas-fir and Sitka Spruce resins each contained 13 volatile components  $\geq 1\%$ , while Western Hemlock had 12 (Table 2). Volatile compounds in Douglas-fir and Western Hemlock resins were all terpenoids (mono-, sesqui- and diterpenes). Sitka Spruce was the only species with non-terpenoid esters and no sesquiterpenes. There were four compounds ( $\alpha$ -pinene, myrcene, limonene, and  $\beta$ -phellandrene) common to all three species, but in substantially different proportions (Table 1). In Douglas-fir,  $\beta$ -pinene,  $\alpha$ -pinene, and sabinene were the three most abundant components representing 66.40% of the resin. In Western Hemlock, limonene/ $\beta$ -phellandrene, myrcene, and  $\alpha$ -pinene made up 60.90% of the resin, whereas myrcene, limonene/ $\beta$ -phellandrene, and piperitone made up 48.19% of the Sitka Spruce resin.

## Discussion

Our results confirm that, by avoiding the resin ducts in conifer needles, tree voles are able to dramatically reduce the terpenoid contents of their diet. However, we have noticed that captive tree voles occasionally ingest whole needles, including the resin ducts. The exact proportion and variability of whole needles consumed is not known for any of the conifer hosts that we examined. There are numerous other mammalian herbivores that ingest resinous conifer tissues and preferentially select individual plants, plant parts, or chemically-mediated diets with lower concentrations of these compounds (Radwan et al. 1982; Snyder 1992; Kimball et al. 1998; Vourc'h et al. 2002). Many questions remain regarding the amount of resin ingested with whole needles, what impact the resin has on vole physiology, and what physiological mechanisms they use to process the resins.

TABLE 2. Mean percentage composition of volatile compounds in the needle resin of three conifer species used for forage by Red Tree Voles (*Arborimus longicaudus*) in Oregon.<sup>1</sup> Compounds are listed according to their retention times, and only those that comprised >1% of the total integrated peak area within a species are shown.

Compound	Douglas-fir	Western Hemlock	Sitka Spruce
$\alpha$ -Pinene	12.47	14.53	1.17
Camphene	—	—	1.01
Sabinene	11.65	—	—
$\beta$ -Pinene	42.28	7.99	—
Myrcene	2.07	15.63	33.10
$\alpha$ -Phellandrene	—	1.93	1.14
Limonene/ $\beta$ -Phellandrene <sup>2</sup>	1.88	30.74	7.63
1,8-Cineole <sup>3</sup>	—	—	1.55
(z)- $\beta$ -Ocimene	1.29	5.73	—
Terpinolene	5.13	—	—
Isopentyl isovalerate <sup>4</sup>	—	—	4.71
Ester C10? <sup>4</sup>	—	—	2.82
Camphor <sup>3</sup>	—	—	2.74
Piperitone <sup>3</sup>	—	—	7.46
Citronellyl acetate <sup>3</sup>	1.52	—	—
$\alpha$ -Humulene	3.33	—	—
Germacrene D	3.51	1.61	—
$\gamma$ -Cadinene	—	1.56	—
$\delta$ -Cadinene	—	2.19	—
Sesquiterpene C15 <sup>5</sup>	4.40	2.10	—
Diterpenes <sup>6</sup>	4.05 (2)	4.30 (2)	28.16 (3)
Cumulative Total	93.58	88.31	91.50
Monoterpene hydrocarbon	72.37	74.45	44.06
Monoterpene oxygenated	5.92	2.10	11.75
Sesquiterpene hydrocarbon	6.84	5.36	—
Sesquiterpene oxygenated	4.40	2.10	—
Diterpenes	4.05	4.30	28.16
Non-terpene esters	—	—	7.53

<sup>1</sup> Mean calculated from the 10 whole and 10 cut needles of each species, since cutting the needles would not impact their resin composition.

<sup>2</sup> Both compounds present in all three species.

<sup>3</sup> Oxygenated monoterpene.

<sup>4</sup> Non-terpene ester (oxygenated).

<sup>5</sup> Oxygenated sesquiterpene, possibly an isomer of germacrene D-4-ol.

<sup>6</sup> The diterpenes were not identified, but were all different among the three species, with the number of compounds  $\geq 1\%$  in parentheses.

The terpene resins that tree voles ingest in whole needles likely contribute to host recognition and reinforcement of their strong host specificity. We and others (Walker 1930; Clifton 1960; M. Johnson, unpublished notes) have noted that captive tree voles raised from infancy on one species of conifer may reject needles from other species and may starve if suddenly switched to a diet of needles from an unfamiliar species. Tree voles are coprophageous and the young ingest fecal pellets from their mother before their eyes open (Hamilton 1962). Passage of host terpenes from mother to offspring in fecal matter could be the initial step in developing host specificity or possibly insuring gut inoculation with microbes that help metabolize the resin. In addition, needle sizes and shapes among conifer species are similar but not identical, and as shown here the resin ducts are located in different positions. Having learned from their mother how to feed

on a particular species with discrete needle characteristics, tree voles are unable to learn quickly how to feed on a different species.

The thin strips of Douglas-fir tissue containing resin ducts are typically used by the voles as building material for their nests (Howell 1926; Maser et al. 1981), whereas nest building from the same needle tissues of Western Hemlock and Sitka Spruce nest is more variable. Male European Starlings (*Sturnus vulgaris*) co-mingle fresh herb tissues rich in volatile compounds into their nests, resulting in fewer bacteria, no adverse impact from mites, and fledglings with greater body mass compared to nests without these herbs (Gwinner and Berger 2005). It is unknown whether vole nests constructed from the tissue fibers with resin ducts provide similar benefits. At present, utilization of this material for nest building appears to be a value-added benefit, and not the primary reason for their removal.



Within the forests of western Oregon, tree voles are most frequently found in Douglas-fir, occasionally in Western Hemlock, and more rarely in Sitka Spruce, and Grand Fir. Undoubtedly there have been many factors influencing the tree vole adaptation of host specificity for Douglas-fir. At the fine spatial scale of a single host tree, terpenoid resins probably influence their diet selection. This then raises the question of what role the terpene resins may play in host species selection and specificity. Our study was not designed to compare characteristics of the terpene resins among the three host species that we examined, but our results do point to potential differences that warrant further study. For example, Douglas-fir, without the removal of resin ducts, appears to be the best choice among the three species, because it provides the lowest resin concentration (0.77% dry weight). Alternatively, Sitka Spruce appears to be the least preferred host and it was the most chemically different from the other two. It had the highest concentration of terpenoids (Table 1) with a lower monoterpene content, no sesquiterpenes, and about seven times more diterpenes than Douglas-fir and Western Hemlock (Table 2). In addition, Sitka Spruce foliage needles contain alkaloids (Gerson and Kelsey 2002) not present in the other two species that may also function as defensive chemicals (Tawara et al. 1993) or decrease palatability for the voles. Environmental effects on resin characteristics can be ruled out as causing the differences between Sitka Spruce and Western Hemlock because the trees sampled were from the same site. Sitka Spruce needles also had the most variable terpene concentrations, as would be expected for tissue with discontinuous resin ducts that vary in length and position or that occasionally may be absent (as observed for one whole needle here). The Sitka Spruce we sampled had resins only in the basal half of the needle, but Weng and Jackson (2000) found Sitka Spruce trees with resin ducts only in the apical half of needles, and others with ducts that extended the entire needle length. Whether there is enough variability among spruce trees in the proportions of their needles without resin ducts, including those with no resin ducts in any of the needles (Weng and Jackson 2000), to influence host selection by voles would be an interesting possibility to explore.

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# Phenology, Population Dynamics, and Flowering Dynamics of Case's Ladies'-tresses, *Spiranthes casei* var. *casei* (Orchidaceae), in Ottawa, Ontario

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Reddoch, Joyce M., and Allan H. Reddoch. 2008. Phenology, population dynamics, and flowering dynamics of Case's Ladies'-tresses, *Spiranthes casei* var. *casei* (Orchidaceae), in Ottawa, Ontario. *Canadian Field-Naturalist* 123(1): 19-31.

We describe a seven-year study (2002–2008) of a population of Case's Ladies'-tresses (*Spiranthes casei* var. *casei*) in the western Greenbelt in Ottawa, Ontario, that had been extant since at least 1972. We also record a temporary colonization in the eastern Greenbelt for 11 years (1998–2008). The seven life history stages identified were seed, juvenile, immature, flowering, vegetative, offshoot (ramet), and non-emergent. Mature plants present in the first two years of the study had mean half lives of 9.4 years. Flowering and seed production were limited by damp, cloudy weather when fall rosettes develop, by gastropod herbivory in early summer, by drought in mid-summer, and by deer herbivory in late summer. Given the resulting wide fluctuations in the fractions of plants flowering, as well as the lack of visibility of vegetative plants, this study demonstrates the limitations of annual censuses of flowering stems for determining the actual sizes of populations and for detecting long-term population trends.

**Key Words:** Case's Ladies'-tresses, *Spiranthes casei*, Brown-lipped Snail, *Cepaea nemoralis*, Banded Wood Snail, *Stethobaris ovata*, White-tailed Deer, *Odocoileus virginianus*, flowering dynamics, gastropod, herbivory, long-term study, population dynamics, Ottawa, Ontario.

Case's Ladies'-tresses (*Spiranthes casei*, pronounced *case-eye*) was described in 1974 by Catling and Cruise (1974). This species is restricted to portions of the Great Lakes – St. Lawrence and Acadian Forest Regions of eastern North America (Rowe 1972; Bailey 1998\*). It occurs in parts of Nova Scotia, New Brunswick, southern Quebec, southern Ontario and adjacent border states as far west as Minnesota (Sheviak and Brown 2002; NatureServe 2008\*). In Ontario, the centre of its distribution, the species is ranked “apparently secure”, the same rank that it has been assigned globally (S4, G4; Natural Heritage Information Centre 2008\*; NatureServe 2008\*). The species is considered “critically imperiled” in the three other Canadian provinces where it occurs (S1, NatureServe 2008\*).

*Spiranthes casei* is a late-summer-flowering plant with up to 50 yellowish white flowers arranged in a single spiral on a flowering stem up to 49 cm high (Sheviak and Brown 2002, personal observations). The flowers are agamospermic and also bee pollinated (Catling and Catling 1991). Capsule production generally approaches 100% in eastern Ontario and western Quebec (Reddoch and Reddoch 1997). Like *S. magnicamporum* Sheviak and *S. cernua* (L.) L.C. Richard on the prairies (Sheviak 1991), *S. casei* is adapted to summer drought by having fugaceous basal leaves and descending, tuberous roots. Populations inhabit dry to moist, shallow to deep sands in old fields, grasslands, abandoned sand pits, open woodlands, roadsides and powerline corridors, and on acidic rock outcrops and ridges (Catling and Cruise 1974; Luer 1975; Brackley

1985; Whiting and Catling 1986; Case 1987; Reddoch and Reddoch 1997; Catling and Brownell 1999).

Little has been published on the population dynamics of the species. Case (1987) stated that in the western Great Lakes region *Spiranthes casei* was “a colonizer of disturbed sites, developing large populations briefly then waning rapidly.” Reddoch and Reddoch (1997) described two long-lived populations in the Ottawa area. One population, in the Stony Swamp Conservation Area, Ottawa, Ontario, in 1996 had survived for at least 26 years in an area where the soil was too thin to support dense vegetation. This population is the major subject of the current study. The other population, in Gatineau Park, Quebec, 20 km to the north, in 1996 had persisted for at least 16 years in a field that had been mowed annually. After mowing was discontinued in about 2000, there was rapid succession to a young, dense White Pine (*Pinus strobus* L.) forest. We last found *S. casei* plants there in 2006. We also reported (Reddoch and Reddoch 1997) that populations on dry sites were particularly affected by drought and that, as a result, very few or no plants flowered in some years.

The European *Spiranthes spiralis* (L.) Chevall. is one of the few *Spiranthes* species for which population dynamics and flowering patterns have been studied over the long term (Kull 2002; Light and MacConaill 2005). This species has a phenology somewhat similar to that of *S. casei*, one significant difference being that all of the leaves of *S. spiralis* are produced in the fall (Wells 1967, 1981; Tatarenko and Kondo 2003). Wells (1981) followed an English population of *S.*

*spiralis* for 17 years, and Willems and colleagues (Willems 1989, 2002; Willems and Dorland 2000; Jacquemyn et al. 2007) a Dutch population for 24 years. These observers found that the number of plants changed somewhat from year to year, but that flowering was extremely variable. Both groups (Wells 1981; Jacquemyn et al. 2007) observed cohort half-lives of up to nine years. Wells (1981) concluded that conservation and management of orchid populations depend on an understanding of phenology and population dynamics, especially recruitment, mortalities, survivorship, and longevity of individual plants.

The goals of this study were to establish the life history, phenology, leaf production and longevity of *Spiranthes casei* plants in a population in the Stony Swamp Conservation Area, as well as their population and flowering dynamics. We also examined the longevities of this and seven other populations in the same conservation area. In the Mer Bleue Conservation Area, we followed a temporary colonization that possibly originated from a single plant. From our observations, we derived some implications for the conservation and management of *S. casei* populations.

## Study Sites

Both study sites were in the National Capital Commission Greenbelt surrounding the urban core of the City of Ottawa, Ontario, on the lowlands of eastern Ontario. The climate is continental, with warm, moist summers and cold, snowy winters (Crowe 1984). The mean daily maximum and minimum temperatures over the 1971–2000 period were 26.5°C and 15.4°C in July, and -6.1°C and -15.3°C in January. The mean annual precipitation was 944 mm distributed fairly evenly throughout the year. The mean frost free period was about 159 days, extending, on average, from the beginning of May to early October (Environment Canada 2008\*).

The major part of the work was done in the Stony Swamp Conservation Area (45°18'N, 75°49'W; 115 m above mean sea level), a 20 square km composite of second-growth forests, conifer plantations, marshes, beaver ponds, old fields, and scattered expanses of exposed, flat-lying bedrock. The bedrock is sandstone, interbedded with sandy dolomite in some places, of the Nepean and March formations (Wilson 1938; Bélanger and Harrison 1980). Within eastern Ontario and western Quebec close to Ottawa, *Spiranthes casei* is essentially concentrated in the Stony Swamp Conservation Area (Reddoch and Reddoch 1987, 1997).

The primary study site was a 1.4 ha opening of exposed sandstone surrounded by a second-growth forest dominated by *Acer saccharum* Marsh., *Fraxinus americana* L., *Quercus rubra* L., and *Pinus strobus* L. The opening is clearly visible in air photos back to 1945, the earliest coverage of the area available at the National Air Photo Library, Ottawa. The *Spiranthes casei* plants were spread along the northern edge of the

opening within a strip about 200 m long and 50 m wide (Figures 1 and 2). They grew in thin layers of sand over bedrock or in cracks in the bedrock. A few specimens of the forest tree species and of the following species, *Acer rubrum* L., *Frangula alnus* Miller, *Populus grandidentata* Michx., *P. tremuloides* Michx., *Picea glauca* (Moench) Voss, and *Betula papyrifera* Marsh., were scattered across the opening. The most common shrub was *Juniperus communis* L. The most common grasses were *Danthonia spicata* (L.) Beauv. and *Panicum lanuginosum* Elliott var. *implicatum* (Scribner) Fernald. Rosettes of the latter made it difficult to distinguish the similarly sized and shaped juvenile/immature plants and emerging leaves of *S. casei*. *Vaccinium angustifolium* Ait. and *V. myrtilloides* Michx. were the most frequent companion plants. Other herbs that occurred within 50 cm of *S. casei* plants were *Rumex acetosella* L., *Hypericum perforatum* L., *Hieracium caespitosum* Dumort. ssp. *caespitosum*, *Packera paupercula* (Michx.) A. Löve & D. Löve, *Solidago nemoralis* Ait., and, occasionally, *Cypripedium acaule* Ait., *Malaxis unifolia* Michx., *Spiranthes lacera* (Raf.) Raf. var. *lacera*, and *Spiranthes cernua*.

The second study site was in the Mer Bleue Conservation Area (45°24'N, 75°31'W; 75 m above mean sea level), 25 km east of the Stony Swamp Conservation Area, at a location that we have frequented since 1966 while monitoring a population of *Spiranthes cernua* there (Reddoch and Reddoch 1997). In 1966 the site was part of a large, recently abandoned borrow pit of well-drained sand that was devoid of vegetation; currently it is somewhat shaded by well-spaced *Populus tremuloides* trees that lost some of their canopy in the January 1998 ice storm (Figure 3). In the vicinity of the *S. casei* plants were several *P. tremuloides* saplings up to 1 m high. The ground cover included *Danthonia spicata*, *Trifolium repens* L., *Packera paupercula*, and *Polytricum* mosses. The shade and deep sand distinguish this habitat from those at Stony Swamp. At both sites, the substrates were acidic sands of pH 4.0–4.5 (Reddoch and Reddoch 1997).

## Materials and Methods

Guided by a mixed specimen sheet of *Spiranthes casei* and *S. cernua* at the Vascular Plant Herbarium, Agriculture and Agri-Food Canada (DAO), collected by C. and E. Frankton (#2385) in 1972, we relocated *S. casei* (and *S. cernua*) at the collection site in the Stony Swamp Conservation Area in 1977 (Reddoch and Reddoch 1997). From then on we monitored *S. casei* flowering plants on an infrequent basis at this and seven other populations in the Conservation Area. The populations were 100–500 m in extent. The location of the 1972 collection became our primary study site in 2002 when we initiated a detailed examination of all plants encountered. We continued to check the other Stony Swamp populations from time to time until 2008.





FIGURE 1. The central portion of the Stony Swamp Conservation Area study site. Note the deer browse line on the trees. Photograph taken 23 August 2008. All photographs by Joyce Reddoch.

At the Stony Swamp study site between 2002 and 2008, we followed a total of 152 individuals (genets and ramets) of *Spiranthes casei*: 112 mature individuals and 40 juvenile/immature individuals. Of the mature individuals, only six were within 5 cm of other individuals and could possibly be interpreted as vegetative offshoots (ramets). Because these possible offshoots represented only 4% of the population, we did not distinguish between genets and ramets in this paper. For the most part, plants were detected initially when they were in flower. Juvenile/immature plants were discovered only occasionally when they were in the vicinity of established plants. We made three visits between the beginning of May and the end of June to measure and count leaves, and two trips in July (and sometimes one in early August) to record the appearance and condition of flowering shoots/stems. We returned at flowering time in August to count flowers, to measure flowering stems, and to record their condition and the occurrence of deer herbivory. We came back again at seed release time at the beginning of October to note surviving reproductive stems, and before freeze-up in early to mid-November to measure and mark the leaves of the fall rosettes. We measured the first two leaves on fall rosettes between 2005 and 2008 ( $n = 253$  fall rosettes) and all available third to seventh leaves ( $n = 210$ ) in 2005 and 2006. We made total leaf counts between

2005 and 2008. The graphs were based on the data derived from the Stony Swamp population; data collection concluded in November 2008.

In 1998 we discovered a flowering plant of *Spiranthes casei* at the Mer Bleue site and began to track it, as well as the total of 14 juvenile/immature plants that appeared in a 1 m<sup>2</sup> area adjacent to and south of it. We visited this site following the same protocol and schedule as at Stony Swamp.

At all locations we took care to walk only on exposed bedrock or along designated routes to avoid altering the habitat or stepping on juvenile/immature and vegetative plants. We mapped the plants and marked them by bracketing each one with small plastic rods that could be removed at the end of the study. We kept track of the leaves by numbering each one with a system of dots made with a fine-point permanent marker.

In 1979 and 1986, we collected a total of 40 flowering and vegetative plants of *Spiranthes casei* ahead of residential development in the Bridlewood subdivision adjacent to the western boundary of the Stony Swamp Conservation Area. We deposited representative herbarium sheets at the Vascular Plant Herbarium, Agriculture and Agri-Food Canada (DAO), and examined all specimens held by that herbarium and the National Herbarium of Canada (CAN). These specimens provided information on the morphology of juve-

nile/immature plants, as well as of the tuberous roots, and fall shoots/buds of flowering and vegetative plants.

Records of temperature and precipitation (Environment Canada 2008\*) originated at the Macdonald-Cartier (Ottawa) International Airport weather station (elevation 114 m above mean sea level), which is about 12 km from each study site. Vascular plant nomenclature followed that of the Ontario Natural Heritage Information Centre (2008\*), except that Dore and McNeill (1980) was used for grasses.

Corel Quattro Pro X3 provided descriptive statistics, *t*-tests, ANOVA (analysis of variance), and regression analysis. In addition, a more generalized program was set up in Quattro to do ANOVA with samples of unequal size following, in part, Sokal and Rohlf (1994). Half-lives were obtained by linear regression analysis of log-transformed annual population counts of marked plants.

Results

Life History

We encountered seven life history stages: seed/protocorm, juvenile, immature, flowering, vegetative, non-emergent, and offshoot (Figure 4). Some of these stages could be assigned with confidence only after the plants had been followed for a number of years. The interface between juvenile and immature stages was not clear-cut. We define the juvenile stage as the initial leafy stage of plant growth that lasted one year (Figure 5). The subsequent immature stage continued to develop over several years until the plant flowered. A mature plant is one that is in flower or has flowered, and can be flowering, vegetative or non-emergent in a given year.

Offshoots were defined to be those individuals that appeared within 5 cm of another individual, either from flowering or vegetative plants. Since it was seldom possible to determine unambiguously whether new individuals in the vicinity of mature plants were offshoots or juvenile plants, we use the term “plant” to mean any individual, whether genetically related to other individuals or not. We reported previously (Reddoch and Reddoch 1997) that vegetative reproduction, as expressed by pairs or clumps of individuals, was insignificant in this species in the Ottawa area. In this study, there were six mature plants (genets) with a mature

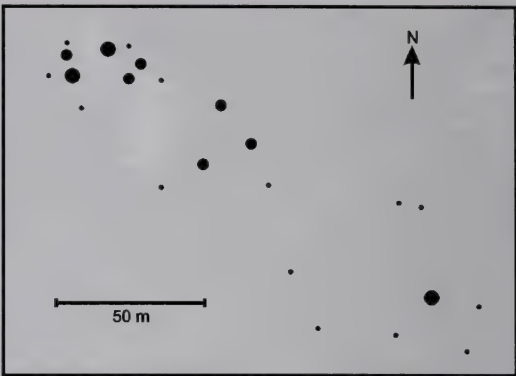


FIGURE 2. Map of the distribution of all *Spiranthes casei* plants studied at the Stony Swamp site. Small dots represent 1–4 individuals, medium dots 5–10 individuals, and large dots 20–25 individuals.

putative offshoot (ramet) within 5 cm and an additional six mature plants with immature putative offshoots. Vegetative reproduction in other *Spiranthes* species occurred by the production of a bud on the underground stem or at the root tip (Catling 1989). The former is the more likely form of vegetative reproduction in *S. casei* because most of the putative offshoots were within one cm of the original plant.

Phenology and Leaf Production

Except as noted, this section is based on our observations of *Spiranthes casei* plants in the field, on our collected specimens, and on herbarium specimens. The aerial part of next year’s growth began as a lanceoloid shoot appearing above ground at anthesis (Mousley (1924, sub *S. cernua* var. *ochroleuca*), Reddoch and Reddoch 1997). The shoots of vegetative plants initiated their development up to a month earlier than those of flowering plants. Plants with flowering stems that had dried up or had been decapitated accidentally before flowering also produced their shoots earlier than plants that supported intact flowering stems (Reddoch and Reddoch 1997). In *S. spiralis*, also, the leaves of vegetative plants appeared earlier than those of flowering plants (Wells 1981).

TABLE 1. Mean annual leaf numbers on fall rosettes of plants that had been vegetative, of plants that had flowered, and of the combined vegetative and flowering plants. (SE = standard error.)

		2005	2006	2007	2008
Vegetative	mean ± SE	2.31 ± 0.12	1.72 ± 0.14	2.03 ± 0.08	2.26 ± 0.08
	number	29	29	58	42
Flowered	mean ± SE	1.82 ± 0.16	1.23 ± 0.12		1.83 ± 0.14
	number	22	47		23
Combined	mean ± SE	2.10 ± 0.10	1.42 ± 0.09	2.03 ± 0.08	2.11 ± 0.08
	number	51	76	58	65





FIGURE 3. Habitat of the temporary colonization in the Mer Bleue Conservation Area in 1998. The founder plant is circled. The trees in the background show the effects of the January 1998 ice storm. Photograph taken 23 August 1998.

During September and October, the shoots developed into rosettes of two (occasionally one, three or four) leaves with a growing tip in the centre (Figure 6, Table 1). Plants that had flowered that summer sometimes produced only a growing tip. The first and second leaves were generally ovate in shape and were 0.2–2.5 cm wide and 0.2–3.5 cm long. Mean lengths ( $\pm$  standard error) for the first two leaves (2005–2008)

were  $1.21 \pm 0.05$  cm,  $n = 190$ , and  $1.97 \pm 0.05$  cm,  $n = 161$ , respectively.

Fall rosettes had more leaves on plants that had been vegetative that summer than on those that had flowered (Table 1). In 2005, 2006, and 2008, there were significantly more leaves on the fall rosettes of plants that had been vegetative ( $t$ -tests:  $t_{2005} = 2.5$ ,  $P < 0.02$ ,  $df = 49$ ;  $t_{2006} = 2.6$ ,  $P < 0.01$ ,  $df = 74$ ;  $t_{2008} = 2.9$ ,  $P < 0.01$ ,

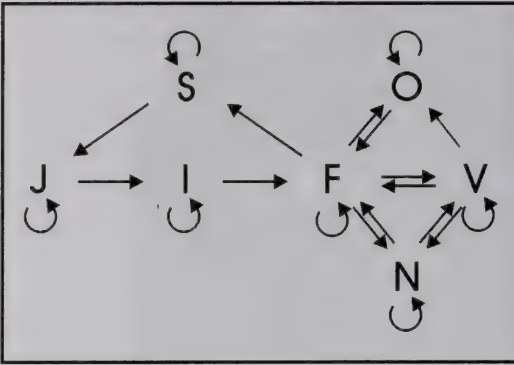


FIGURE 4. Life history diagram of *Spiranthes casei* in eastern Ontario. Arrows represent annual transitions between stages; S = seed and protocorm, J = juvenile, I = immature, F = flowering, V = vegetative, N = non-emergent, and O = offshoot (ramet) stages. The arrows directed upward to seed and offshoot stages represent reproductive transitions.



FIGURE 5. A juvenile *Spiranthes casei* plant in the Stony Swamp Conservation Area. The length of the second leaf, on the left, was 2.3 cm. Photograph taken 24 July 2006.

df = 63). A comparison in 2007 was not meaningful because only two plants flowered. The rosettes overwintered under the snow; the first two leaves generally did not grow further in the spring except on late-developing rosettes.

In the spring, vegetative plants continued on to produce a total of 3–6 leaves (occasionally 2; once 9 at the Mer Bleue site), while flowering plants had a total of 5–6 (occasionally 4 or 7) leaves (Figure 7). By late May, the third leaf had reached its final size, with lengths of 3.0–9.5 cm and widths of 1.0–1.9 cm. The fourth, fifth and sixth leaves had finished growing by the beginning of July with lengths of 6–15 cm and widths of 1.0–1.8 (rarely to 2.1) cm. The seventh leaf, when it occurred, continued to grow until mid-July, into a similar size range. These leaves were oblanceolate to linear-lanceolate, arranged in sub-opposite pairs, each pair at right angles to the previous pair. At the beginning of July, the original pair of leaves had turned yellow to brown or had already disappeared. During July, depending on the temperature and precipitation, the remaining leaves remained green or became brown at their tips or turned entirely brown. Thus it was difficult to find intact leaves on which their maximum lengths could be measured. Usually all of the basal leaves were brown at anthesis.

In a plant that was preparing to flower, the growing tip of the flowering stem was evident in late June to early July and continued to extend and develop through July and August. There were usually four (range three to five) cauline bracts, the upper ones appressed and the basal one or two often wide-spreading and leafy. These basal-cauline leafy bracts were sometimes still green at anthesis, long after the basal leaves had become brown and shriveled. The buds were clearly visible by early August, arranged in three vertical or

slightly twisted ranks, spiraling upwards opposite to the direction that the flowers were going to face. At anthesis, between mid-August and early September, there were generally six flowers per turn in one long spiral. The flowering stems were 8.5–46.5 cm high (mean  $24.4 \pm 0.51$  cm,  $n = 138$ ), inflorescence heights were 3–16.5 cm high (mean  $7.7 \pm 0.23$  cm,  $n = 119$ ), and there were 4–45 flowers/inflorescence (mean  $20.9 \pm 0.68$ ,  $n = 129$  inflorescences). Seed capsules dehiscent and released seed throughout October.

Mousley (1942; sub. *Spiranthes vernalis*) reported that the buds of the first pair of tuberous roots for the next year were evident in late September. We found that such root-buds had not developed further by mid-April, and confirmed Mousley's observation (Mousley 1924; sub. *S. cernua* var. *ochroleuca*) that the early stages of root expansion were present in mid-May. At anthesis, we noted that the crisp, white, descending roots of the year extended down over the soft, brownish roots of the previous year.

To discover whether there was a relationship between the total number of basal leaves and the probability of a mature plant flowering, we marked and counted the basal leaves on all available mature plants between 2005 and 2008. We found that plants with two or three leaves were always vegetative, while plants with four, five or six leaves were either vegetative or flowering





FIGURE 6. A fall rosette of a *Spiranthes casei* plant in the Stony Swamp Conservation Area. The first leaf, right, was 1.7 cm long, and the second leaf, left, was 2.2 cm long. Photograph taken 1 November 2008.

(Figure 7). Flowering plants had five or six (rarely four or seven) leaves, and a quarter to almost a half of vegetative plants also had five or six leaves. Except in 2007, a plant with five leaves had a 43% to 66% probability of flowering, and one with six leaves a 56% to 75% probability. The probability of a plant with seven leaves flowering was 100%. An exception to the rule that the more leaves on a mature plant the more likely it is to flower occurred one year at the Mer Bleue site when the mature plant there produced nine leaves while remaining vegetative (see above).

Juvenile plants had three leaves (Figure 5); immature plants produced up to 5 (rarely 6) leaves that were up to 9 cm long. Immature plants followed the same pattern of leaf production as vegetative plants.

#### Population Dynamics

In this section and a following section on flowering dynamics, we present the data derived from the Stony Swamp study site in two datasets. The first dataset shows the annual changes in the marked mature plants that we followed from year to year through the growing seasons (Figures 8a and 10a). The second dataset provides a summary of the annual demographic information on all of the mature plants in the population, i.e., the marked plants and the newly-found plants (Figures 8b and 10b). In addition, we report observations

on the juvenile and immature plants that we encountered by chance while monitoring the mature plants.

The marked mature plants yielded annual information on the total number of such plants, the number that were consumed by gastropods before the flowering stems could emerge in early July, the number of surviving plants that initiated flowering stems, the number that remained vegetative, and the number that were non-emergent. This information is presented in Figure 8a and expanded on below.

Gastropods included both slugs and snails, especially the conspicuous Banded Wood Snail (*Cepaea nemoralis* Linnaeus). Each year, gastropod damage was evident on the leaves of many plants. However, in addition, gastropods consumed all of the above-ground parts of some plants, including an unknown number of potential flowering stems. Such complete gastropod herbivory between 2003 and 2008 ranged from 6% of the plants in 2005 to 39% in 2008, the six-year mean being 17% (Figure 8a). The high percentage of gastropod herbivory in 2008 was likely the result of exceptionally wet summer weather (Environment Canada 2008\*) when frequent, often light, rain kept the ground wet from June to early August (personal observation) and provided ideal conditions for gastropod activity. Of the total of 31 mature plants that sustained gastropod herbivory between 2003 and 2007, eight died the

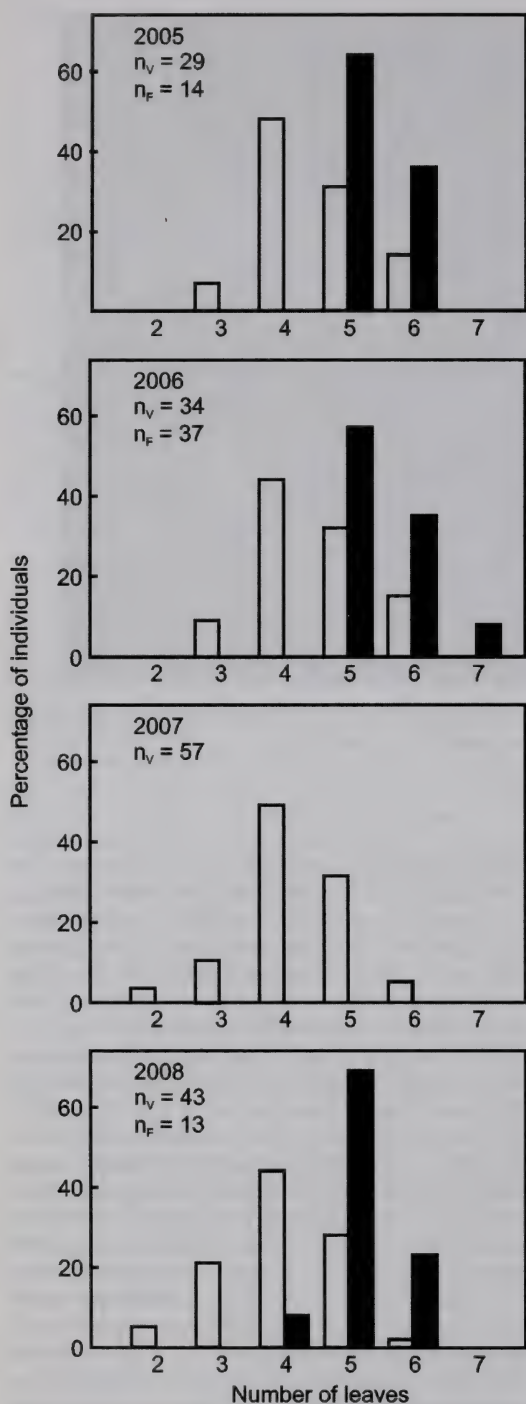


FIGURE 7. The distribution of the number of basal leaves of mature vegetative (white bar) and flowering (black bar) plants (2005–2008). Percentages represent leaves on vegetative and flowering plants separately. There were only two flowering plants in 2007, one each with four and five leaves (not plotted).

year following herbivory, six flowered, one did not emerge (see below) and the rest remained vegetative.

In addition to gastropod herbivory, weevils (*Stethobaris ovata* (LeConte, 1868)) damaged the leaves of several *Spiranthes casei* plants. Two specimens were collected on 13 June 2008 and deposited in the Canadian National Collection of Insects, Ottawa. *Stethobaris ovata* is known to feed on a number of orchids in North America (Howden 1995; Dunford et al. 2006); this appears to be the first record of its occurrence on *Spiranthes*.

Initiation of flowering stems in the marked mature plants that survived gastropod herbivory varied between 18% of the total marked mature plants in 2008 and 49% in 2006 (Figure 8a). These values exclude the exceptionally low-flowering year of 2007, when only two plants flowered, and the unrealistically high value of 90% in 2002 that reflected our lack of awareness of existing vegetative plants at the beginning of the study.

Non-emergence was an infrequent occurrence (Figure 8a). Between 2003 and 2008, a total of seven mature plants did not emerge for one year each, while one additional mature plant did not emerge for two consecutive years. The life stages before and after non-emergence (using a hyphen for a non-emergent year, F for a flowering year and V for a vegetative year) were as follows: three V–V, two F–V, one V–F, one F–F, and one F–F. One of the plants that was non-emergent between two vegetative years had been eaten by gastropods in the initial year (see above). Two immature plants also were non-emergent for one year. Only one of the mature plants that had been non-emergent has since died. Non-emergence did not appear to be a symptom of senescence as it was for the tuberous orchid *Platanthera hookeri* (Reddoch and Reddoch 2007a).

Overall, the total number of mature plants observed increased annually for the first four years of the study (Figure 8b), likely reflecting our growing knowledge of the population, particularly in the first two years. The increase in numbers came from the annual addition of new flowering plants. Between 2004 and 2008, the new flowering plants contributed 40% to 55% of the annual total of flowering plants and 15% to 25% to the annual total of mature plants. In 2007 there were no new flowering plants.

The total number of juvenile/immature plants present during the study was not known because they were so difficult to find. Of the 40 juvenile/immature plants that we did discover, we were able to follow only two of them from first emergence to flowering. One of them flowered three years after first emergence and the other flowered after two years. Other juvenile/immature plants persisted for up to six years after emergence without flowering. Using asymbiotic culture of several batches of *Spiranthes casei* seeds from the Stony Swamp Conservation Area, Marilyn Light (per-



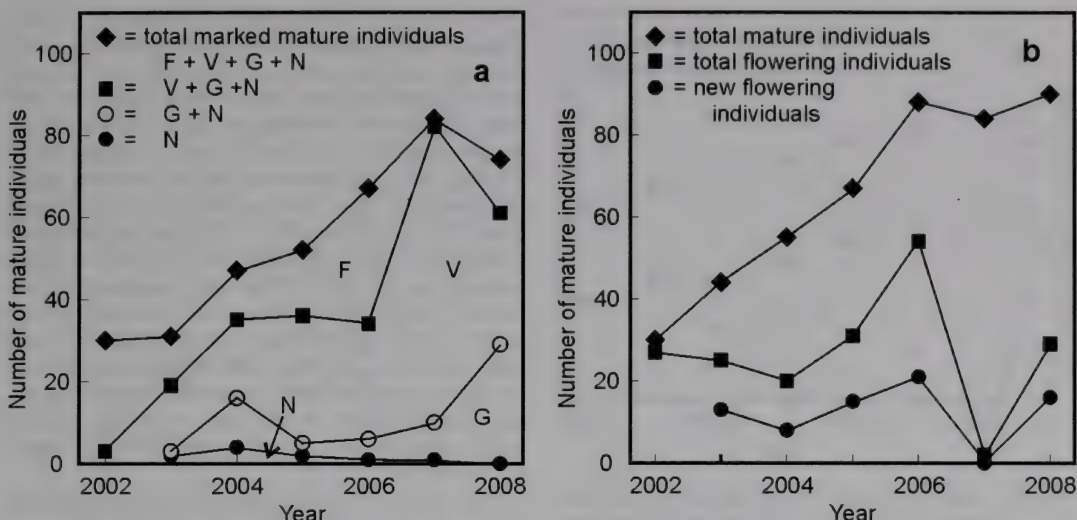


FIGURE 8. Population dynamics (2002–2008). a) The annual stage distributions of marked mature plants: F = initiated flowering stems, V = vegetative, and N = non-emergent. G = plants eaten by gastropods before intent to flower was evident. b) The annual counts of total mature plants and of total flowering plants. The annual counts of newly-discovered flowering plants are also shown.

sonal communication) observed some swollen embryos within a month of sowing and 0% to 95% germination two months later. Six months after sowing, the germinated seeds had produced small plants with three green leaves, the third one not completely unfurled. This rate of asymbiotic development is comparable to that observed for *S. cernua* (Stoutmire 1964), *S. lacera* (sub *S. gracilis*) and *S. romanzoffiana* Cham. (Oliva and Arditti 1984), and *S. spiralis* (Wells and Kretz 1983).

Mortality of juvenile and immature plants appeared to be quite high; for example, of the 26 known juvenile/immature plants present in 2007, only seven reappeared in 2008.

#### Plant and Population Longevities

One of the goals of this study was to determine a range of lifetimes for individual mature plants as well as for populations; however, it is now apparent that the average lifetimes of the mature plants in this population were longer than the extent of the study. Of the 30 mature plants recorded at the Stony Swamp study site in 2002, 19 (63%) were still alive in 2008. Three of those plants had been known since 2001 and one since 1998. Of the increased total of 42 mature plants present in 2003, 29 (69%) were still extant in 2008. In Figure 9, the annual numbers of mature plants for the 2002 and 2003 datasets are shown as depletion curves on a semi-log plot. These two depletion curves yielded essentially identical half-lives for mature plants of  $9.48 \pm 0.69$  and  $9.41 \pm 0.46$  years, respectively, which are equivalent to mean lifetimes (half-life/ $\ln 2$ ) of 13.7 and 13.6 years.

Including the study site which is the subject of this paper, all eight populations of *Spiranthes casei* in the Stony Swamp Conservation Area that were first recorded between 1972/1981 and 2008 were still extant. The majority of the plants were in sandstone barrens that remained relatively unchanged because the shallow sandy soil inhibited succession (Reddoch and Reddoch 1997). In 2008, some additional plants persisted in remnant openings among secondary forest growth adjacent to the open barrens. Generally, then, *Spiranthes casei* populations can persist for more than three decades in relatively stable habitats.

#### Temporary colonization

In September, 1998, in the Mer Bleue Conservation Area, we encountered for the first time a single flowering plant of *Spiranthes casei* at the southern edge of a *S. cernua* population that we had been monitoring for a number of years. Since we knew the area very well, we were fairly certain that this was the first time that a *S. casei* plant had flowered there. The plant flowered again in 2000 but did not flower again. In an area 1 m square to the south of the original plant, we discovered six juvenile/immature plants in 1999, six more in 2000, one in 2003, and one more in 2007. The first 13 juvenile/immature plants died within four years, the mean survival time after we discovered them being three years. In 2008, two plants remained, the original plant and the immature plant discovered in 2007. If there were no other *S. casei* populations closer than those at Stony Swamp, it is possible that we were the inadvertent vectors carrying the seed(s) to this locality.

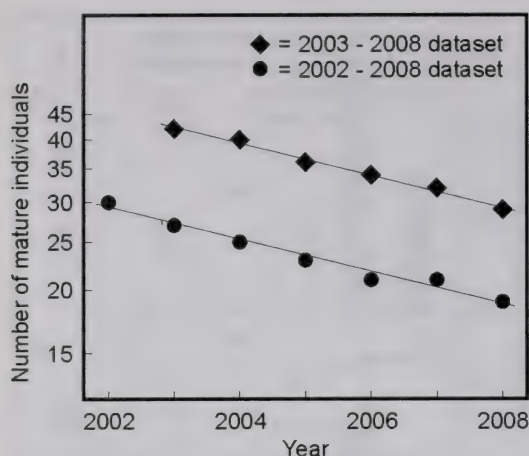


FIGURE 9. Depletion curves for the mature plants that were present in 2002, and that were present in 2003, on a semi-log scale. The lines were derived from least-squares fits of  $\ln$  vs. time.

#### Flowering Dynamics

For the marked plants (Figure 10a), hot summer weather between early July, when flowering stem shoots first appeared, and mid-August, when the flowers began to open, caused some of the developing flowering stems to desiccate and shrivel. Between 2002 and 2006, the proportion of desiccated stems ranged from 17% in 2004, when July and August temperatures were slightly below the 30-year normal, to 56% in 2005, when July and August temperatures were  $1.6^{\circ}\text{C}$  above normal. Rainfall in both years was close to normal (Environment Canada 2008\*). The mean loss to desiccation for the period 2002–2006 was 41%. Neither of the two flowering stems present in 2007 dried up, nor did any of the 13 flowering stems in the wet, cool summer of 2008.

During the course of this study, we frequently observed White-tailed Deer (*Odocoileus virginianus*) at the study site and elsewhere in Stony Swamp, reflecting the widespread problems of high deer densities in Eastern Ontario and Stony Swamp in particular (Broadfoot and Voit 2000\*, Widenmaier and Fahrig 2006\*). At the study site between 2000 and 2005, a deer browse-line developed at a height of 1.5 m on the trees both in the opening and throughout the surrounding forest (see Figure 1), and our deer sightings became more common. Deer herbivory of *Spiranthes casei* stems began when some of the flowers were open and was evidenced by the shredded tip of the remaining part of the stems. Annual herbivory by White-tailed Deer of the marked inflorescences between mid-August and early October ranged from 8% in 2008 to 67% in 2003 (Figure 10a). The mean deer herbivory over the years 2002–2008 was 33%. The percentage of marked flowering stems that survived to produce seed in early October ranged from 0% in 2002 to 92% in 2008.

At anthesis in late August, the total number of flowering stems in the field was the sum of the marked stems that survived to flowering and the newly-discovered stems (Figures 8b, 10b). Annual White-tailed Deer herbivory of the total flowering stems present in August ranged from 18% in 2006 to 77% in 2003 (Figure 10b). Overall, then, the percentage of all flowering stems that produced seed between 2003 and 2008 ranged from 23% in 2003 to 82% in 2006, the six-year mean being 56%. The year 2002 had one of the hottest, driest summers on record with half of the normal July and August precipitation and with temperatures  $1.3^{\circ}\text{C}$  above normal (Environment Canada 2008\*). Under these conditions, 33% of the 27 flowering stems observed that year dried up even during anthesis. In the years 2003 to 2006, some flowering stems dried up while expanding in July and August, but not at anthesis (see above).

The year 2007 was exceptional for the small number of plants that flowered (Figures 8 and 10). The plants of 2007 developed from fall rosettes that formed in September and October of 2006. These 2006 fall rosettes had significantly fewer leaves than those that formed in 2005, 2007 and 2008 (Table 1; ANOVA  $F_{[3,246]} = 15.4$ ,  $P < 0.001$ ). Taken separately, the fall rosettes of vegetative and flowering plants also had significantly fewer leaves in 2006 (Table 1; ANOVA  $F_{[3,154]} = 5.6$ ,  $P < 0.002$ ; ANOVA  $F_{[3,89]} = 6.9$ ,  $P < 0.002$ , respectively).

One factor that could have contributed to smaller fall rosettes in 2006 was the exceptionally high September and October precipitation, which was 170% of normal. In addition, more rain implies more cloudy weather as well as less sunshine and warmth. In fact, the mean number of hours that were "Clear" or "Mainly Clear" between 8 a.m. and 4 p.m. Eastern Standard Time in September and October of 2006 (1.9 hrs/day) was significantly less than in the same period of 2005 (3.5 hrs/day), 2007 (3.6 hrs/day), and 2008 (3.1 hrs/day; Environment Canada 2008\*; ANOVA  $F_{[3,240]} = 3.4$ ,  $P < 0.02$ ).

Flowering patterns of individual plants were highly variable. Of the 24 mature plants present for the five years 2002–2006, 50% flowered twice, 17% once, and 17% three times. Two of the plants flowered every year but one, and two flowered all five years. For the whole population, 54% of the mature plants flowered consecutively for at least two years between 2002 and 2006.

#### Discussion

Long-term studies are essential for understanding the behaviour of orchid populations (Kull 2002; Light and MacConaill 2005; Pfeifer et al. 2006; Jacquemyn et al. 2007; Reddoch and Reddoch 2007a, 2007b). Ideally such studies should last at least as long as the average lifetimes of the individual plants. Studies lasting two or more decades may be necessary to acquire a comprehensive picture of the population and to find



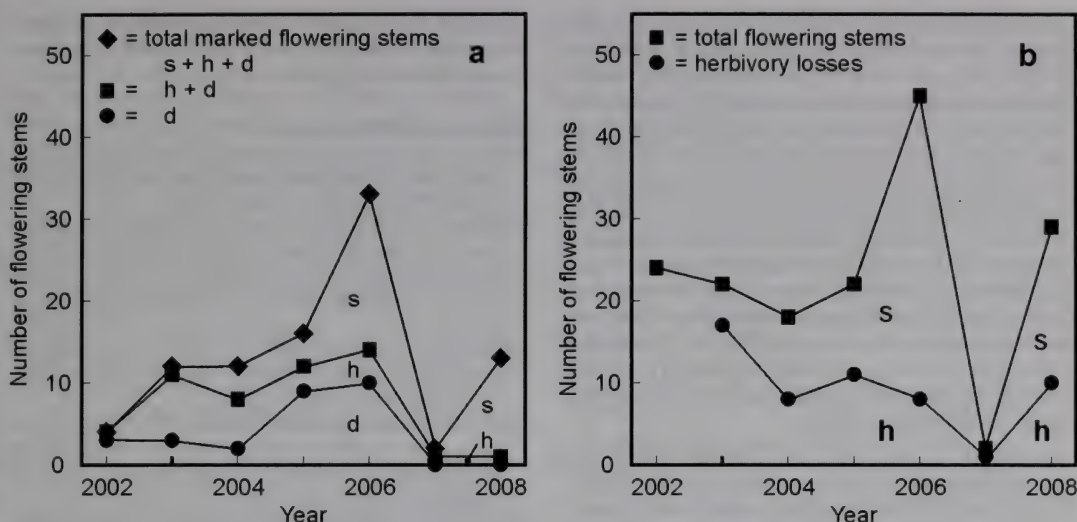


FIGURE 10. Flowering dynamics (2002–2008). a) The annual fates of the marked flowering stems from emergence in July until seed dispersal in October, showing the stems lost to drought (d) and to deer herbivory (h), and the stems that survived to disperse seed (s). b) The annual losses to deer herbivory of all of the flowering stems present at flowering time from mid-August until seed dispersal in October (h), and the flowering stems that survived to disperse seed (s).

correlations of population and flowering dynamics with external factors such as weather. But even a seven-year study of a species such as *Spiranthes casei*, with a mean mature plant lifetime of 13.7 years, can yield some useful insights.

The populations of *Spiranthes casei* in the arrested subclimax conditions of the Stony Swamp Conservation Area have persisted for more than three decades. Individual mature plants that were present in the study area in 2002 and in 2003 yielded half lives of about 9.4 years, a value close to the half-life range of 4.6–9.2 years found for annual cohorts of *S. spiralis* (Wells 1981, Jacquemyn et al. 2007). Seeding, rather than vegetative reproduction, was the main source of new plants and thus of the continuity of the populations. The temporary colonization of the rapidly-changing seral community at the Mer Bleue Conservation Area seems to depend on one individual, which has been present as a mature plant for at least 11 years. It is likely that plant lifetimes are dependent on the stability of their habitats, and, therefore, that plant lifetimes at the Mer Bleue Conservation Area would be different from those at Stony Swamp.

There are a number of factors that affect whether a mature *Spiranthes casei* plant will produce flowers. The more leaves on a plant, the greater the probability of it flowering. This observation is consistent with the behaviour of other tuberous orchids, for example, *Ophrys apifera* Hudson (Wells and Cox 1989) and *Himantoglossum hircinum* Spreng. (Pfeifer et al. 2006). After flowering, the fall rosettes of flowering plants developed later and had significantly fewer leaves than did plants that had been vegetative, suggesting that flower-

ing did have an impact on the plants' resources. In addition, though, since all fall rosettes, from both flowering and vegetative plants, were smaller in 2006 than in other years, the decrease in 2006 was not a consequence of the large flowering (62%) that year but rather had other causes.

It is not clear whether flowering one year reduces the probability of flowering again the next year. About half of the mature plants of *Spiranthes casei* in the Stony Swamp study area flowered consecutively for at least two years in a five-year period, while the Mer Bleue individual flowered only twice, in non-consecutive years. By comparison, in Nebraska, two-thirds of the *S. cernua* plants in a population that had been studied for nine years flowered for at least two consecutive years (Antlfinger and Wendel 1997), while only 15% of a Dutch *S. spiralis* population did so during an 18-year study (Willems and Dorland 2000).

Fall weather appears to have a considerable influence on whether mature plants will flower or not in the following year. In *Spiranthes casei*, reduced exposure to sunlight during the time of rosette development in the fall of 2006 was followed by significantly smaller fall rosettes and almost no flowering in 2007. Here, the resource being limited was the energy required for photosynthesis, and also, perhaps, for triggering flower formation. In addition, the preference of *S. casei* for well-drained sites suggests that extended periods of very high rainfall could have a direct negative impact on development. Thus, the very high rainfall, combined with much less sunshine, may have led to smaller fall rosettes, and, consequently, to significantly fewer flowering plants in the following year. Summer weather was

a factor in determining whether flowering stems, once initiated, reached the flowering state (Figure 10a). Rock barrens and open areas of well-drained sand are particularly susceptible to drought in hot, dry summers.

Herbivory can have a serious impact on *Spiranthes casei* plants. Gastropods not only ate parts of leaves but also killed both juvenile/immature and mature plants. Prolonged periods of wet weather in May and June could allow gastropods to have a serious impact on a population. White-tailed Deer have become an increasing problem in the Stony Swamp Conservation Area since about 2000 (Widenmaier and Fahrig 2006\*; personal observations). Deer ate the *S. casei* flowers, thus reducing the annual seed production, but did not directly kill any plants. The long-term effects of deer herbivory are difficult to predict.

In summary, then, there were several external factors, acting separately or in combination, that resulted in reduced flowering. Damp, cloudy, fall weather reduced the sizes of the fall rosettes. Damp, cloudy, early summer weather enhanced gastropod activity that eliminated above-ground parts of some plants; hot, dry summers desiccated some developing flowering stems; and deer consumed some inflorescences once they had formed. The impact of damp weather depended not so much on how much rain fell but rather on how continuously damp, cloudy conditions occurred.

This study shows that the censuses required for sound management of orchid populations such as *Spiranthes casei* must be preceded by extensive and intensive fieldwork. A one-time census at flowering time is of limited value besides confirming that the population is "still there". Even annual censuses of flowering stems do not give a realistic idea of the population size or trends because these counts can vary dramatically from year to year as a result of different weather effects and herbivory. In addition, vegetative and non-emergent plants are not visible at flowering time to be counted. Thus the management goals for a population should include ongoing tracking of all plants in a suitably large sampling area. As well, habitats must be maintained in an early stage of succession if this is not the natural consequence of shallow soils. Annual mowing late in the fall after seed release or very early in the spring before leaf growth begins is essential for controlling woody plants. Adequate drainage and a suitable moisture regime also must be maintained.

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# Multi-scale Cover Selection by White-tailed Deer, *Odocoileus virginianus*, in an Agro-forested Landscape

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Resource selection studies are commonly conducted at a single spatial scale, but this likely does not fully or accurately assess the hierarchical selection process used by animals. We used a multi-spatial scale approach to quantify White-tailed Deer (*Odocoileus virginianus*) cover selection in south-central Michigan during 2004–2006 by varying definitions of use and availability and ranking the relative importance of cover types under each study design. The number of cover types assigned as selected (proportional use > proportional availability) decreased from coarse (landscape level) to fine (within home range) scales, although at finer scales, selection seemed to be more consistent. Although the relative importance changed substantially across spatial scales, two cover types (conifers, upland deciduous forests) were consistently ranked as the two most important, providing strong evidence of their value to deer in the study area. Testing for resource selection patterns using a multi-spatial scale approach would provide additional insight into the ecology and behavior of a particular species.

Key Words: White-tailed Deer, *Odocoileus virginianus*, cover selection, selection indices, spatial scale, use-availability, Michigan.

Selectivity, as described by Johnson (1980), relates to an animal's use of some resource (e.g., cover) disproportionately to its availability; this assumes that resources used in a proportion higher than their availability (i.e., "selected") are more important than those resources used in a proportion less than their availability (i.e., "avoided"). Under this premise, highly selected resources should contribute positively to an animal's fitness (Garshelis 2000), with the opposite true for highly avoided resources.

The seemingly simple concepts related to selection, however, can translate into complex issues during studies of resource selection. For example, how availability is defined can impact how selection and avoidance are assigned (Buskirk and Millspaugh 2006). There is a relationship between the spatial extent of availability and the spatial scale of study for the selection process (Otis 1997), and as the defined spatial extent of availability is reduced, selection may become more difficult to detect (McClellan et al. 1998; Alldredge and Griswold 2006). Other potential problems include different statistical techniques providing different selection results (Garshelis 2000) and availability defined by non-ecological boundaries (e.g., political boundaries, roads) providing potentially spurious results (Porter and Church 1987; Buskirk and Millspaugh 2006).

Single-scale studies are commonly used to describe resource selection (Thomas and Taylor 2006), although it may be advantageous to consider studying selection at >1 spatial scale (Manly et al. 2002). The distribution of most species is not uniform, regardless of

the spatial scale of study, due in part to the distribution of food and predators (Stephens and Krebs 1986). These factors suggest that resource selection may best be examined by varying definitions of resource use and availability at different spatial scales (e.g., availability could be defined as proportion of each cover type within a home range or proportion of each cover type within the study area). A multi-scale approach could reveal interesting selection patterns and reduce potential errors associated with human-induced definitions of availability (or use).

By considering the hierarchical selection process used by organisms to meet their habitat requirements (Johnson 1980; Morrison et al. 1992), researchers can make inferences about habitat selection at multiple spatial scales. Using a multi-scale approach, while considering the natural history of an organism, should improve our understanding of the ecology of that organism. For example, within a landscape, what coarse-scale features do White-tailed Deer (*Odocoileus virginianus*) select (e.g., cover types characterizing a home range), and what landscape features (e.g., area of developed land) potentially affect selection? Within the home range, what habitat components do deer select (e.g., within-patch characteristics), and what is the relationship between these components and deer behavior (e.g., selection of adequate thermal refugia)? If we assume that deer generally avoid urbanized areas within a landscape (coarse-scale approach), but deer exist locally in high densities within certain urbanized areas, then what are the differences in resource



selection, movements, and other behavioral characteristics (e.g., selection of areas closed to hunting) between urban and rural areas?

Our objective was to assess differences in cover selection by adult female White-tailed Deer at multiple spatial scales by varying definitions of resource use and availability. By varying these definitions, for example, spatial patterns of resource selection may emerge to confirm the importance of consistently selected cover types and clarify which cover types may be structurally interchangeable. Because sex- and age-class resource-selection differences exist for White-tailed Deer (Main et al. 1996; Kie and Bowyer 1999; Stewart et al. 2003) and deer abundance on our study area was above management goals, the sex-age class of interest for our study was adult female deer.

### Study Area

Our study was conducted in eastern Jackson, western Washtenaw, and southwestern Livingston counties in south-central Lower Michigan (Figure 1). Our study-area boundary was defined specifically to include all townships containing 1 deer location estimate. The study area (8 townships totaling 82 636 ha) included publicly and privately owned lands. South-central Michigan has been characterized by a relatively high deer density ( $\sim 27/\text{km}^2$  during fall 2005; Michigan Department of Natural Resources 2005\*) and increasing urbanization and other land-use changes. The study area was primarily rural (98% of total land area), but the human population increased 16% and housing units increased 22% between 1990 and 2000 (U.S. Census Bureau 2003\*). Much of the landscape throughout southern Michigan is expected to experience changing land-use activities (e.g., increasing urbanization) similar to the study area (Madill and Rustem 2001\*). Most agriculture in Jackson and Washtenaw counties (total area = 366 483 ha) was corn (37 840 ha) and soybean (34 200 ha) production (Michigan Department of Agriculture 2002\*), with about 52% of the study area composed of agricultural land use and about 25% composed of forested land-cover types (Table 1).

Elevation of the study area ranged approximately 180–300 m and consisted of relatively limited relief (Sommers 1977). During 1971–2000, the average annual snowfall was 99.3 cm, average annual precipitation was 77.9 cm, and mean monthly temperatures ranged from  $-5.4^\circ\text{C}$  (January) to  $21.8^\circ\text{C}$  (July) in Jackson County (Midwestern Regional Climate Center, Champaign, Illinois, USA). Our study area had a 150-day growing season (i.e., the average annual accumulation of daily mean temperatures  $>5.6^\circ\text{C}$ ), generally occurring from 10 May to 7 October (Sommers 1977).

### Methods

#### Capturing Deer

We trapped deer during winter (December–March) 2004–2006, using single-door collapsible live traps



FIGURE 1. Study area (shaded) was defined as townships containing  $\geq 1$  deer location estimate, south central Michigan, USA, during 2004–2006.

(Clover 1954). Ages of individuals were estimated through general morphometric differences (e.g., shape and size of head, body size) and dental characteristics (Severinghaus 1949); ages of necropsied individuals later confirmed accuracy of a subset of field observations. We classified deer as fawn ( $< 1$  year old), yearling ( $\geq 1$ – $< 2$  year old), or adult ( $\geq 2$  years old), and reclassified fawns and yearlings on 1 June as they aged, but we used only adult deer for our analyses. Female deer were fitted with metal ear tags (Style 681; National Band and Tag, Newport, Kentucky, USA) and mortality-sensing radio-collars (Model 500; Telonics, Incorporated, Mesa, Arizona, USA; Model G2000; Advanced Telemetry Systems Incorporated, Isanti, Minnesota, USA) with VHF capabilities. The Michigan State University's All-University Committee on Animal Use and Care approved capturing and handling procedures (Application Number 01/04-006-00).

#### Estimating Locations

We located all deer 2–5 times/week using triangulation methods (White and Garrott 1990) or from visual observations of known individuals. To increase the potential of our analyses to accurately describe cover selection, deer were located at varying time schedules on a diel basis, with  $\geq 1$  nocturnal location/deer/week except during capture periods (Beyer and Hauffer

TABLE 1. Cover-type classification system based on a GIS for study area located in eastern Jackson, western Washtenaw, and southwestern Livingston counties, south central Lower Michigan, USA, during 2004–2006.

Cover Type	Description	Study Area (%)
Agriculture	Non-vegetated farmland, row crops, forage crops	52.3
Conifer	Pines ( <i>Pinus</i> spp.), other upland conifers	1.5
Herbaceous openland	Herbaceous vegetation with <25% woody cover	2.9
Lowland deciduous forest	>60% composed of lowland deciduous tree cover	8.0
Lowland shrub	Woody shrub cover with >60% non-water cover	9.9
Mixed wetland	Floating aquatic vegetation, emergent wetland, mixed non-forest wetland	3.1
Northern hardwood	>60% canopy cover of maple ( <i>Acer</i> spp.), beech ( <i>Fagus grandifolia</i> ), ash ( <i>Fraxinus</i> spp.), cherry ( <i>Prunus</i> spp.), birch ( <i>Betula</i> spp.)	2.3
Oak association	>60% canopy cover of oak ( <i>Quercus</i> spp.)	1.6
Upland deciduous forest	>60% canopy cover of upland deciduous trees	11.6
Upland shrub	>25% woody cover	<0.1
Urban	Low and high intensity, roads, parks, golf courses	2.8
Water	Surface, flowing	3.9
Other	Aspen ( <i>Populus</i> spp.) association, orchards, bare ground	0.1

1992). For example, we randomly assigned each deer to 1 of 3 groups, then systematically rotated the groups such that each group would be assigned to a different monitoring time period during each day of monitoring. Azimuths were estimated using a 3-element folding Yagi antenna (Advanced Telemetry Systems, Incorporated, Isanti, Minnesota, USA), portable radio receiver (Model R-1000, Communications Specialists, Incorporated, Orange, California, USA), and mirror-sighting compass. A handheld GPS unit (Model GPS IV; GARMIN International, Incorporated, Olathe, Kansas, USA) was used to estimate the locations for triangulations and for locations of visually observed individuals.

Locations and error ellipses from triangulated data were estimated using the program LOCATE III (Pacer, Truro, Nova Scotia, Canada). We used the maximum likelihood estimator as recommended by White and Garrott (1990) and Nams and Boutin (1991). We followed Nams' (1989) technique to estimate the effectiveness of our sample size to describe selection when telemetry error is large. This method is based on developing a ratio between telemetry error-ellipse size and cover-type patch size.

#### Cover-type Classification

We generalized land-use, land-cover data (Michigan Center for Geographic Information 2001\*) using ArcView GIS v3.2 software (Environmental System Research Institute, Redlands, California, USA) and Spatial Analyst Extension to define 13 cover types within the study area (Table 1). Our generalization procedures were used to reduce data complexity to reflect our spatial scale of study, but may have excluded certain fine-scale characteristics (e.g., hedgerows, roads) in some instances.

#### Cover Selection

We assumed that all location estimates that were classified in the cover type water were inaccurate and we relocated each to the nearest alternative cover type.

However, this adjustment did not preclude the potential importance of water, or more specifically, cover near water, as a resource selected for or avoided by individuals. Cover selection was determined seasonally based on agricultural crop production (i.e., the growing season [150 days; 10 May–7 October], and the non-growing season [215 days; 8 October–9 May]) in the study area. We assumed these 2 time periods approximated seasonal differences in resource availability and deer behaviors (e.g., parturition and primary fawn-rearing versus breeding and fasting). Deer that survived multiple seasons were included in the seasonal data set if they had 30 locations/home range (Seaman et al. 1999), though efforts to collect location data may not have been balanced by season (i.e., less effort during deer capture seasons).

Our approach to assess multi-scale cover selection was to first consider the hierarchical selection process proposed by Johnson (1980). Under this concept, our data described second- (i.e., home range selection within the study area) and third-order (i.e., cover selected within a home range) selection (Table 2) for deer. We then applied study designs 1–3 of Thomas and Taylor (1990) to Johnson's (1980) hierarchical selection process to describe cover selection processes of deer and the magnitude of their differences at different spatial scales. We assumed, for example, that if a cover type dominated the selection process at multiple spatial scales, then its relative importance to deer was higher than a cover type selected at 1 spatial scale. Finally, we applied Ivlev's (1961) electivity index to quantify selection based on these varying definitions of use and availability under Thomas and Taylor (1990).

We used SYSTAT v11 (Systat Software, Inc., San Jose, California, USA) for data analyses and used 95% confidence limits (CLs; LCL = lower, UCL = upper) to make comparisons. The use of confidence limits is advantageous in that an estimate of effect size and a measure of uncertainty are provided (Johnson 1999).



TABLE 2. Study designs (and definitions of use and availability used in our study) for collection of use-availability data as described by Thomas and Taylor (1990, 2006) and selection hierarchy as defined by Johnson (1980).

Study design	Scale and Definition		
	Use	Availability	Selection Hierarchy
1	Population-level (study area)	Population-level (study area)	Second-order
2	Individual (kernel home range)	Population-level (study area)	Second-order
3	Individual (location estimates)	Individual (kernel home range)	Third-order

*Landscape-scale selection.* We used design 1 of Thomas and Taylor (1990) to describe second-order selection (Johnson 1980), where both use and availability are defined at the population level (Table 2). We quantified use and availability using Euclidean distances of location estimates to nearest cover types within the study area. Although this analysis method is most often used for linear or point features, it is equally valid for spatial features such as cover types described as polygons (Conner and Plowman 2001). We pooled all location data (i.e., individuals were not identified) and determined the Euclidean distance between each location to each of the nearest cover types within our classification system. To describe availability, we generated 1000 random points from a uniform distribution bound by the study-area boundary and measured Euclidean distances using methods identical to those used for location estimates.

*Meso-scale selection.* Use is estimated for each individual while availability for all individuals is identical under design 2 (Thomas and Taylor 1990), which also described second-order selection (Johnson 1980), but under a differing view of use (Table 2). Under this design, we defined availability as the composition of cover types within the study-area boundaries and use as 95% fixed kernel home ranges. Kernel home ranges were estimated using least-squares cross-validation (Worton 1989; Worton 1995; Seaman et al. 1999) through Animal Movement Extension (Alaska Biological Sciences Center, Glacier Bay, Alaska, USA) in ArcView GIS v3.2 software.

*Fine-scale selection.* Both use and availability are defined at the individual level with design 3 (Thomas and Taylor 1990), which describes third-order selection by Johnson (1980; Table 2). We defined use as the proportion of location estimates of an individual within each cover type, and availability as the proportional area of each cover type within the 95% kernel home range of that individual. Design 3 seemed an appropriate measure of availability at finer spatial scales because kernel home ranges may overestimate space used by an animal (i.e., cover types containing no location estimates are often included in a home range estimate; Guthery et al. 2005; Hiller et al. 2009).

Consequently, we developed two methods to characterize availability of cover types within kernel home ranges: conditional and unconditional presence of cover types. Conditional analyses excluded cover types not present within an individual's home range, while unconditional analyses included all cover types within the study area for the estimation of selection indices.

*Selection Indices.* We used Ivlev's (1961) electivity index to quantify cover selection for each individual and calculated the mean for each cover type by season. This ratio provides an index ranging from -1 (implying avoidance; proportion used < proportion available) to 1 (implying selection; proportion used > proportion available), with 0 (proportion used = proportion available) suggesting random use. Confidence limits for Ivlev's index were truncated at -1 (LCL) or +1 (UCL) when appropriate. We compared selection within and among study designs based on the confidence limits of selection indices (see below) to investigate cover use by deer at multiple spatial scales.

Because point estimates alone may not provide an accurate estimate of resource selection (Hobbs and Bowden 1982), we based selection assignment (i.e., cover types selected, avoided, or randomly used) on confidence limits. Confidence limits were calculated using individuals as the sample unit (data were pooled by season so that an individual deer may have been included in 1 growing or 1 non-growing season). For design 1, confidence limits based on the means and standard errors of Euclidean distances were used to assign selection, but to compare selection with designs 2 and 3, we calculated Ivlev's electivity index based on ratios of mean Euclidean distances. Using mean Euclidean distances as a ratio to assign selection results in mathematical signs opposite (i.e., negative values imply selection) to the results normally obtained with other analytical methods; therefore, we multiplied results of design 1 by -1 to ease comparisons with designs 2 and 3. We followed Strauss (1979) to estimate confidence limits of selection indices under designs 2 and 3.

*Ranking Cover Types.* Using Ivlev's electivity index, we ranked cover types within a study design and growing season by selection indices (i.e., the cover type

TABLE 3. Cover selection by White-tailed Deer ( $n = 20$ ) based on Euclidean distances (m; 95% confidence limits: LCL = lower, UCL = upper) between cover types and location estimates or randomly generated points (1000) within the study area, under design 1<sup>a</sup> of Thomas and Taylor (1990), south-central Michigan, 2004–2006. Location estimates were pooled by agricultural growing season (1626 locations for growing [10 May–7 October], 1867 locations for non-growing season [8 October–9 May]).

Cover type	Season							
	Random		Growing			Non-growing		
	LCL	UCL	LCL	UCL	$I^b$	LCL	UCL	$I$
Agriculture	137.8	175.7	402.1	440.5	−0.39	320.8	351.2	−0.29
Conifer	1549.9	1720.5	487.0	554.6	0.47	454.4	515.6	0.50
Herbaceous openland	682.1	745.1	650.3	688.3	0.00	637.8	669.6	0.01
Lowland deciduous forest	357.2	395.8	353.9	381.8	0.00	371.2	394.8	0.00
Lowland shrub	398.4	459.3	229.0	251.7	0.23	233.7	256.5	0.22
Mixed wetland	1321.4	1476.1	585.9	634.8	0.35	652.6	696.3	0.31
Northern hardwood	712.1	792.6	355.4	377.5	0.31	367.5	386.8	0.30
Oak association	839.3	918.3	513.0	544.4	0.21	505.7	534.5	0.22
Upland deciduous forest	355.7	402.8	122.6	138.3	0.44	133.7	148.6	0.41
Upland shrub	10914.0	11497.3	13502.5	13726.0	−0.08	13167.8	13367.3	−0.07
Urban	1241.0	1349.1	1870.1	1995.4	−0.16	2000.7	2108.3	−0.19
Water	1726.8	1905.9	870.1	953.1	0.29	1007.6	1077.5	0.23
Other	4192.0	4489.5	3807.9	4014.1	0.22	3574.2	3768.1	0.05

<sup>a</sup>Design 1 identifies population-level use and population-level availability. Individuals are not identified.

<sup>b</sup>Selection indices based on Ivlev's (1961) electivity index using mean distance of random points (availability) and used points (use). If 95% CLs overlapped,  $I = 0.00$ ; if CLs of random points > CLs of used points,  $I$  was calculated using LCL of random and UCL of used ( $I > 0$ , implying selection); if CLs of random points < CLs of used points,  $I$  was calculated using LCL of used and UCL of random ( $I < 0$ , implying avoidance). Index was multiplied by  $-1$  to standardize direction of selection (+) and avoidance (−) with other study designs.

with the highest selection index within a set received a rank of 1, and so on). Cover types with identical selection indices within a design and season were assigned identical ranks. To assess overall relative importance, we assigned the average rank ( $\bar{R}_i$ ) among study designs for each cover type  $\bar{R}_i$  within a season based on the equation

$$\bar{R}_i = [\text{design 1} + \text{design 2} + (0.5 \times \text{design 3U}) + (0.5 \times \text{design 3C})]/3,$$

which incorporated the weighted average of the two design 3 methods (U = unconditional, C = conditional). Ranking of cover types among designs were ordered from the lowest  $\bar{R}_i$  (assigned the rank of 1) to the highest  $\bar{R}_i$  (assigned the highest rank value within the set of cover types). Cover types with identical values of  $\bar{R}_i$  were assigned the same rank.

## Results

We captured and radiomarked a total of 42 female deer during our study. A subset of 20 radiomarked adult deer (i.e., captured as adult or that aged into adult during our study) was available for analysis (i.e., individuals with  $\geq 30$  locations; Seaman et al. 1999). This subset contained a total of 3493 location estimates (growing season = 1626 locations, non-growing season = 1867 locations) and a mean of 71 locations/seasonal home range over both seasons (3493 locations divided by 49 seasonal home ranges from 20 deer). We pooled

data by year for each season due to small sample sizes. The growing seasons of 2004, 2005, and 2006 included 7, 14, and 3 deer, respectively. The non-growing seasons of 2004, 2005, and 2006 included 7, 11, and 7 deer, respectively. Five deer were included more than once in one of the two seasons, so individual totals for each season (24 sets of locations for the growing season, 25 sets of locations for the non-growing season) exceeded the total number of deer ( $n = 20$ ) available for analyses.

Using generalization procedures in a GIS and our cover-type classification system, the patch size of cover types on our study area ranged from <1 ha to >11000 ha (e.g., an agricultural matrix) with a mean size of 29.2 ha (94% of patches were <40 ha). For sample size assessment, we estimated a mean telemetry error-ellipse size of 10.2 ha and a mean landscape-patch size of 29.2 ha/patch on our study area, resulting in an ellipse-to-patch diameter ratio of 0.59. This ratio suggested that the appropriate sample size should be twice the normally desired sample size to describe cover use while minimizing bias (see Nams 1989: Figure 3). Because we used only individuals with  $\geq 30$  locations (Seaman et al. 1999), but obtained 2.4 $\times$  that value (i.e.,  $\bar{x} = 71$  locations/deer/home range; range = 30–133), we considered our telemetry data to contain minimal bias for describing cover selection regardless of our assessment method.



### Cover Selection

**Landscape-scale selection.** Under design 1, selection was assigned for 8 and 9 cover types for the growing and non-growing seasons, respectively (Table 3). Selection indices for both seasons ranked conifers and upland deciduous forests as the most highly selected (each  $I > 0.40$ ), while agriculture was the most highly avoided cover type. Although indices differed somewhat between seasons, the patterns of selection were similar when assessed under this design (Table 4). Two cover types moved one rank value (lowland deciduous forest, other), while one cover type (oak association) moved from a rank of 8 during the growing season to a rank of 6 during the non-growing season. All other cover types were ranked consistently between seasons, suggesting no change in relative selection under this study design.

**Meso-scale selection.** The cover types upland shrub and other were absent (i.e., received no use) from kernel home ranges under design 2; consequently, we considered both as highly avoided cover types during both seasons (Table 5). Urban areas were the most highly avoided, but used (i.e., contained locations), cover type during both seasons. Under design 2, we assigned fewer cover types as selected (i.e., based on our definition of selection) in comparison to design 1. Conifers were highly selected, while lowland shrub and upland deciduous forest were moderately selected, with similar selection indices for all three cover types during both seasons. Ranking of cover types by season was similar under design 2 (Table 4). Herbaceous openlands and water each changed in their relative importance between seasons by a value of two; herbaceous openlands became more important and water less important during the non-growing season. Although locations estimated to be in water were moved to the nearest alternative cover type, water was often included within kernel home-range boundaries.

**Fine-scale selection.** Unconditional analysis under design 3 assigned relatively low values for selection to one cover type during each season (upland deciduous forests for growing, conifers for non-growing; Table 6). All other cover types using unconditional analysis were randomly used. The relative importance of cover types changed substantially between seasons (Table 4). Herbaceous openland, mixed wetland, and urban greatly decreased in importance (i.e., rank decreased 4) during the non-growing season; lowland shrub, oak association, and northern hardwood increased in importance (i.e., rank increased 3) during the non-growing season.

Similarly, conditional analysis under design 3, selection included only one cover type during each season, upland deciduous forests during the growing season and conifers during the non-growing season; all other cover types were used randomly (Table 7). The dif-

ference in relative importance between seasons (growing versus non-growing) was greatest for urban (rank decreased by nine) and oak association (rank increased by seven). Moderate differences in importance included mixed wetland (rank decreased by four), herbaceous openland (rank decreased by three), lowland shrub (rank increased by three), and northern hardwood (rank increased by three); all other cover types had a difference in rank of 2 (Table 3).

**Ranking Cover Types.** Using our equation to estimate the mean rank among the study designs, most (77%) cover types had a similar rank between seasons (i.e., rank changed 1; Table 4). During the growing season, mixed wetland increased in relative importance by three and urban increased in relative importance by two, while oak association decreased in relative importance by three. Conifers and upland deciduous forests were the two most important cover types irrespective of season, while agriculture, other, upland shrub, and urban generally were of low relative importance as cover. Although use and availability of water were somewhat inconsistently defined among study designs, the number of locations in water that were moved to the nearest adjacent cover type was  $<0.04\%$  of all locations.

### Discussion

How humans perceive resource availability could be different from how the species under study perceives availability (Litvaitis et al. 1996), which should increase our skepticism of single-scale studies in many instances. If resource selection patterns emerge over multiple spatial scales, it would be logical to assume strong evidence exists for selection of certain resources. Conversely, depending on study objectives, we may question the results of some studies conducted at a single spatial scale, especially if that scale seems to contradict selection patterns based on empirical evidence. For deer, the distribution of hunters and effects of snow and harsh weather may also confound comparisons of cover selection among studies.

The use of Johnson's (1980) system of ranking has been implemented in several ungulate studies. Lopez et al. (2004) used a multi-scale process (first-, second-, and third-order selection) to examine habitat use by Florida Key Deer (*O. v. clavium*) in an increasingly urban environment; they found that Key Deer generally selected for upland vegetation types regardless of spatial scale, and hypothesized that uplands provided preferred foods, cover, and freshwater. In Oregon, the relative importance of 11 plant communities ranked and compared seasonally based on the feeding activities of Mule Deer (*O. hemionus*; individual animals were not identified) and the relative importance of each plant community varied substantially by season (Bodurtha et al. 1989; Table 2). These examples provide evidence that resource selection studies

TABLE 4. Relative importance of cover types by adult female White-tailed Deer ( $n = 20$ ) based on selection indices under multiple study designs (see Thomas and Taylor [1990]), south central Michigan, 2004–2006. Data were pooled by agricultural growing season (growing [10 May–7 October], non-growing [8 October–9 May]).

Season	Study Design <sup>a</sup>				Relative Importance <sup>d</sup>
Cover type	1	2	3U <sup>b</sup>	3C <sup>c</sup>	
<i>Growing</i>					
Agriculture	13	9	7	7	11
Conifer	1	1	2	3	1
Herbaceous openland	9	10	5	6	8
Lowland deciduous forest	9	6	3	4	6
Lowland shrub	6	3	7	8	4
Mixed wetland	3	7	3	4	3
Northern hardwood	4	4	10	10	5
Oak association	8	5	9	9	7
Upland deciduous forest	2	2	1	2	2
Upland shrub	11	12	11	11	13
Urban	12	11	5	1	10
Water	5	8	11	12	8
Other	7	12	11	12	12
<i>Non-growing</i>					
Agriculture	13	9	6	6	10
Conifer	1	1	1	1	1
Herbaceous openland	9	8	9	9	9
Lowland deciduous forest	10	6	3	4	7
Lowland shrub	6	3	3	5	3
Mixed wetland	3	7	8	8	6
Northern hardwood	4	4	7	7	5
Oak association	6	5	5	2	4
Upland deciduous forest	2	2	2	2	2
Upland shrub	11	12	10	10	12
Urban	12	11	10	10	12
Water	5	10	10	10	8
Other	8	12	10	10	11

<sup>a</sup>Designs are based on various definitions of use and availability described in text.

<sup>b</sup>Unconditional analyses included all cover types within the study area for describing selection.

<sup>c</sup>Conditional analyses excluded cover types not present within an individual's home range.

<sup>d</sup>Relative importance ( $\bar{R}_i$ ) = [design 1 + design 2 + (0.5 × design 3U) + (0.5 × design 3C)]/3.

should consider the selection behaviors and natural history of the species of interest. Failure to do so may provide an incomplete understanding of selection processes.

Under the hierarchical selection process, selection at finer scales is dependent on selection at more coarse scales (Johnson 1980), so we would expect selection indices to change based on what we defined as available to individuals or groups of individuals. To illustrate, third-order selection (e.g., the selection of conifers as thermal cover within a home range) is dependent on second-order selection (e.g., the selection of conifers across a landscape). If conifers exist within a home range, but there are no locations within the conifers, we might conclude that conifers were avoided. However, if the proportion of conifers within the home range exceeded the proportion of conifers within the study area, selection is implied. Regardless of the outcome, Johnson's (1980) hierarchical selection process provides a basis from which to study these patterns of selection.

Our analyses showed strong patterns of selection regardless of spatial scale, but there were also some inconsistencies among certain cover types based on changes in their relative importance across multiple spatial scales. Conifers and upland deciduous forests were ranked as the two most important cover types on our study area regardless of the spatial (i.e., study design) or temporal (i.e., season) scale studied. Several cover types changed their relative importance across spatial scales. For example, during the growing season, urban areas shifted from relatively unimportant at the landscape scale to increasingly important as a habitat component within home ranges. Deer near urban areas may have utilized them as fawning cover, although this is based on conjecture.

#### Single-scale Studies

We based our interpretation of selection patterns on past research, but White-tailed Deer habitat is diverse across their geographic distribution, making comparisons somewhat difficult, especially as spatial scale



TABLE 5. Cover selection by adult female White-tailed Deer ( $n = 20$ ) under design 2<sup>a</sup> of Thomas and Taylor (1990), south central Michigan, 2004–2006. Data were pooled by agricultural growing season (150 days; 10 May–7 October; 23 home ranges during growing season, 25 home ranges during non-growing season) within an agro-forested landscape.

Seaso	Presence in home range ( <i>p</i> )	Proportional use		Selection index <sup>b</sup>			
Cover type		<i>p</i>	SE( <i>p</i> )	<i>I</i>	LCL <sup>c</sup>	UCL	Use <sup>d</sup>
<i>Growing</i>							
Agriculture	0.74	0.164	0.047	−0.52	−0.53	−0.51	−
Conifer	0.65	0.154	0.057	0.81	0.31	1.00	+
Herbaceous openland	0.22	0.009	0.007	−0.53	−1.00	0.17	o
Lowland deciduous forest	0.74	0.078	0.024	−0.02	−0.26	0.22	o
Lowland shrub	0.83	0.204	0.038	0.35	0.21	0.48	+
Mixed wetland	0.48	0.022	0.013	−0.17	−1.00	0.82	o
Northern hardwood	0.74	0.045	0.012	0.33	−1.00	1.00	o
Oak association	0.57	0.019	0.007	0.10	−1.00	1.00	o
Upland deciduous forest	0.96	0.288	0.044	0.43	0.33	0.52	+
Upland shrub	0.00	0.000		−1.00			−
Urban	0.09	0.002	0.001	−0.87	−1.00	−0.67	−
Water	0.48	0.015	0.005	−0.44	−0.99	0.11	o
Other	0.00	0.000		−1.00			−
<i>Non-growing</i>							
Agriculture	0.88	0.172	0.033	−0.50	−0.51	−0.49	−
Conifer	0.84	0.162	0.051	0.83	0.35	1.00	+
Herbaceous openland	0.40	0.012	0.006	−0.42	−1.00	0.44	o
Lowland deciduous forest	0.80	0.072	0.019	−0.06	−0.29	0.19	o
Lowland shrub	0.84	0.205	0.039	0.35	0.21	0.49	+
Mixed wetland	0.60	0.027	0.011	−0.07	−1.00	0.95	o
Northern hardwood	0.84	0.033	0.009	0.18	−1.00	1.00	o
Oak association	0.72	0.022	0.007	0.17	−1.00	1.00	o
Upland deciduous forest	1.00	0.282	0.035	0.42	0.32	0.51	+
Upland shrub	0.00	0.000		−1.00			−
Urban	0.08	0.001	0.001	−0.93	−1.00	−0.84	−
Water	0.40	0.012	0.004	−0.53	−1.00	−0.05	−
Other	0.00	0.000		−1.00			−

<sup>a</sup>Design 2 use was based on cover types bounded by 95% fixed kernel home ranges; availability was based on cover types bounded by the study area.

<sup>b</sup>Selection indices based on Ivlev’s (1961) electivity index ( $I$ ).

<sup>c</sup>Confidence limits (95%) were truncated at −1 and 1, and could not be estimated if proportional use = 0.

<sup>d</sup>If 95% CLs >0, selection (+) was assigned; if 95% CLs <0, avoidance (−) was assigned; and if 95% CLs included 0, random use (o) was assigned.

decreases. Harvest management strategies that affect hunting pressure and distribution of hunters may affect the distribution of deer (Harden et al. 2005) and, therefore, the cover selection process that they use. Comparisons along a latitudinal gradient may also be difficult, as weather conditions dictate the vegetation structure used as thermal refugia by deer during harsh conditions. Also, cover-type classifications are not consistent among studies (e.g., use of classification systems specific to individual states or provinces versus National Hierarchical Framework of Ecological Units), further increasing the difficulty of comparisons, especially across the geographic distribution of the White-tailed Deer.

In Arkansas, Miranda and Porter (2003: table 1) used two general habitat suitability classes (food and cover) to model landscape-scale habitat suitability based on cover types, though cover on their study area might

have been utilized by deer for security more so than thermal refugia during winter due to milder winter weather conditions. The suitability of shrublands, deciduous forests, low-intensity residential, and woody wetlands on their study area was high for both food and cover, whereas evergreen forests served primarily as cover, and grassland-herbaceous and agricultural cover types served primarily as food. Water, high-intensity residential, and various other cover types were generally considered unsuitable. Although we found lowland shrubs to be relatively important during the non-growing season, this cover type was not as important on our study area as suggested by Miranda and Porter (2003), perhaps due to differences in species composition between areas. Conifers (e.g., Eastern Redcedar [*Juniperus virginiana*]) on our study area may have contributed cover and some winter food value (see Bender and Haufler 1994) based

TABLE 6. Cover selection by adult female White-tailed Deer ( $n = 20$ ; design 3<sup>a</sup> of Thomas and Taylor [1990]) pooled by agricultural growing season (150 days; 10 May–7 October; 23 home ranges during growing season, 25 home ranges during non-growing season) in an agro-forested landscape in south-central Michigan, 2004–2006. Proportional use and selection indices were unconditional on presence of cover types within home ranges.

Season	Proportional use		Selection index <sup>b</sup>			
Cover type	<i>p</i>	SE( <i>p</i> )	<i>I</i>	LCL <sup>c</sup>	UCL	Use <sup>d</sup>
<i>Growing</i>						
Agriculture	0.154	0.046	−0.03	−0.12	0.05	o
Conifer	0.168	0.063	0.04	−0.05	0.14	o
Herbaceous openland	0.009	0.008	0.00	−1.00	1.00	o
Lowland deciduous forest	0.081	0.026	0.02	−0.23	0.27	o
Lowland shrub	0.191	0.041	−0.03	−0.10	0.03	o
Mixed wetland	0.023	0.015	0.02	−1.00	1.00	o
Northern hardwood	0.030	0.009	−0.20	−0.76	0.36	o
Oak association	0.016	0.006	−0.09	−1.00	1.00	o
Upland deciduous forest	0.325	0.057	0.06	0.02	0.10	+
Upland shrub	0.000					
Urban	0.002	0.002	0.00	−1.00	1.00	o
Water	0.000					
Other	0.000					
<i>Non-growing</i>						
Agriculture	0.162	0.038	−0.03	−0.11	0.05	o
Conifer	0.192	0.058	0.08	0.01	0.17	+
Herbaceous openland	0.005	0.004	−0.41	−1.00	1.00	o
Lowland deciduous forest	0.074	0.025	0.01	−0.27	0.30	o
Lowland shrub	0.206	0.042	0.01	−0.06	0.06	o
Mixed wetland	0.018	0.009	−0.20	−1.00	1.00	o
Northern hardwood	0.026	0.012	−0.11	−1.00	0.80	o
Oak association	0.022	0.011	0.00	−1.00	1.00	o
Upland deciduous forest	0.294	0.046	0.02	−0.02	0.06	o
Upland shrub	0.000					
Urban	0.001					
Water	0.000					
Other	0.000					

<sup>a</sup>Design 3 use was based on proportion of locations in each cover type averaged over individuals; availability was based on mean proportion of area of cover types bounded by individual 95% fixed kernel home range by season. Cover types absent from a home range had proportional availability = 0.

<sup>b</sup>Selection indices based on Ivlev's (1961) electivity index (*I*).

<sup>c</sup>Confidence limits (95%) were truncated at −1 and 1, and could not be estimated if proportional use = 0.

<sup>d</sup>If 95% CLs >0, selection (+) was assigned; if 95% CLs <0, avoidance (−) was assigned; and if 95% CLs included 0, random use (o) was assigned.

on their relative importance (Table 4); the importance of upland deciduous forests (food and cover) on our study area seemed consistent with Miranda and Porter (2003) at the landscape level.

In Midwestern agricultural areas, White-tailed Deer utilize agricultural crops throughout the year (Gladfelter 1984). Regardless of season, we found that agricultural areas increased in relative importance as spatial scale decreased (i.e., scale of selection became finer). This suggests that agricultural areas were much less important to deer at the landscape scale in comparison to providing a habitat component (food) within deer home ranges. This may explain why crop damage by deer seemed to be localized near field edges bordered by cover, at least for relatively large fields; smaller fields may have crop damage throughout (K. Bissell, Michigan Department of Natural Resources, personal communication; Braun 1996). Approximately half of the study area was composed of agricultural areas, which was probably at a much higher proportion than to provide optimal conditions for White-tailed Deer (Hiller et al. 2009).

*Issues of Scale*

Cover selection by deer on our study area showed scale effects. From coarse to fine scale, or as the spatial extent of availability declined, fewer cover types were assigned as selected (i.e., proportional use > proportional availability), similar to McClean et al. (1998). Eight cover types were selected by deer under design 1 (landscape scale), while three and two cover types were selected by deer under design 2 (meso-scale) and each variant of design 3 (fine scale), respectively. Our landscape-scale definition of availability encom-



TABLE 7. Cover selection by adult female White-tailed Deer ( $n = 20$ ; design 3<sup>a</sup> of Thomas and Taylor [1990]) pooled by agricultural growing season (150 days; 10 May–7 October; 23 home ranges during growing season, 25 home ranges during non-growing season) in an agro-forested landscape south-central Michigan, 2004–2006. Proportional use and selection indices were conditional on presence of cover type within home ranges.

Season	Proportional use		Selection index <sup>b</sup>			
	<i>p</i>	SE( <i>p</i> )	<i>I</i>	LCL <sup>c</sup>	UCL	Use <sup>d</sup>
<i>Growing</i>						
Agriculture	0.209	0.062	−0.03	−0.10	0.04	o
Conifer	0.258	0.089	0.04	−0.03	0.12	o
Herbaceous openland	0.043	0.036	0.00	−1.00	1.00	o
Lowland deciduous forest	0.109	0.033	0.01	−0.20	0.22	o
Lowland shrub	0.230	0.044	−0.04	−0.09	0.02	o
Mixed wetland	0.048	0.030	0.01	−1.00	1.00	o
Northern hardwood	0.041	0.012	−0.20	−0.65	0.26	o
Oak association	0.028	0.009	−0.08	−1.00	1.00	o
Upland deciduous forest	0.339	0.058	0.06	0.03	0.09	+
Upland shrub						
Urban	0.026	0.026	0.18	−1.00	1.00	o
Water	0.000					
Other						
<i>Non-growing</i>						
Agriculture	0.183	0.041	−0.03	−0.09	0.03	o
Conifer	0.228	0.067	0.08	0.02	0.14	+
Herbaceous openland	0.013	0.009	−0.38	−1.00	1.00	o
Lowland deciduous forest	0.091	0.030	0.01	−0.20	0.21	o
Lowland shrub	0.245	0.046	0.00	−0.04	0.05	o
Mixed wetland	0.029	0.014	−0.22	−1.00	0.64	o
Northern hardwood	0.031	0.014	−0.11	−0.77	0.55	o
Oak association	0.031	0.015	0.02	−1.00	1.00	o
Upland deciduous forest	0.294	0.046	0.02	−0.01	0.05	o
Upland shrub						
Urban	0.00					
Water	0.00					
Other						

<sup>a</sup>Design 3 use was based on proportion of locations in each cover type averaged over individuals; availability was based on mean proportion of area of cover types bounded by individual 95% fixed kernel home range by season. Cover types absent from a home range were not considered available to respective individuals.

<sup>b</sup>Selection indices based on Ivlev's (1961) electivity index (*I*).

<sup>c</sup>Confidence limits (95%) were truncated at −1 and 1, and could not be estimated if proportional use = 0.

<sup>d</sup>If 95% CLs >0, selection (+) was assigned; if 95% CLs <0, avoidance (−) was assigned; % CLs included 0, random use (o) was assigned.

passed the entire study area. Movements of individual radiomarked deer on our study area were limited to much smaller areas (i.e., a patchy distribution of deer) than the entire study area, suggesting that resource availability may have been overestimated.

Design 2 and design 3 (conditional and unconditional) seemed most appropriate to describe cover selection by deer in our study area, as selection was fairly consistent among designs. Considering our biological knowledge of White-tailed Deer, these designs supported our expectations of cover use by deer. For example, under design 2, conifers, lowland shrubs, and upland deciduous forests were selected regardless of season, perhaps as a result of the relative proximity of cover types. Under each variant of design 3, conifers

were selected during the non-growing season and upland deciduous forests were selected during the growing season.

Human perceptions of wildlife cover selection, as defined through use and availability, may also be affected by landscape characteristics. For example, landscape characteristics (e.g., patch size, shape, and distribution across a landscape) probably affect the distribution of wildlife species, such as White-tailed Deer, in a given area (Porter and Church 1987). The landscape matrix of our study area consisted of relatively few large patches (i.e., >120 ha) of agricultural areas, which probably were in excess quantity relative to the space-use needs of White-tailed Deer (Hiller et al. 2009). Consequently, at the landscape scale, un-

known but perhaps large portions of the study were avoided or not used by deer.

## Conclusions

We used use-availability data of White-tailed Deer to illustrate how and why a multi-scale approach (i.e., various methodological approaches describing use and availability) can be used to describe cover selection and increase our knowledge of deer ecology. If, for example, selection was considered only under design 1, the importance of lowland deciduous forest (Table 4) might be underestimated for White-tailed Deer. Similarly, the oak association cover type may show no difference in relative importance between seasons (under design 2), but the relative importance as defined through a multi-scale analysis could show a relatively large difference among spatial scales (Table 4) that may not otherwise be considered.

We suggest using multiple spatial scales when assessing resource selection, assuming appropriate use-availability data were collected. This should improve the interpretation of resource selection analyses through stronger evidence of selection or avoidance through a relatively comprehensive description of cover use. Specific research objectives, however, may not warrant the use of a multi-scale approach, such as a fine-scale study on screening cover at bedding sites used by White-tailed Deer. When the appropriate scale of study for an application is unknown, the relative importance of cover types across multiple scales should provide insight into cover selection, and therefore value of cover, for the wildlife species under study. Errors of assignment (e.g., effects of inappropriately defined resource availability) may also be minimized and overall selection patterns should emerge through such an approach.

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# Leech (Annelida: Hirudinea) Infestations on Canadian Turtles, Including the First Canadian Record of *Helobdella modesta* from Freshwater Turtles

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We collected leeches from freshwater turtles at two sites in southwestern Ontario. Five leech species (*Placobdella parasitica*, *P. ornata*, *Helobdella modesta*, *Erpobdella punctata* and *Alboglossiphonia heteroclita*) were collected from five turtle species (*Chrysemys picta*, *Chelydra serpentina*, *Clemmys guttata*, *Emydoidea blandingii* and *Sternotherus odoratus*). We report a new leech record (*P. ornata*) for *C. guttata*. The unexpectedly high frequency of *H. modesta* on freshwater turtles is discussed.

**Key Words:** leech parasitism, *Chrysemys picta*, Painted Turtle, *Clemmys guttata*, Spotted Turtle, *Emydoidea blandingii*, Blandings Turtle, *Sternotherus odoratus*, Stinkpot, *Placobdella parasitica*, *Placobdella ornata*, *Helobdella modesta*, *Erpobdella punctata*, *Alboglossiphonia heteroclita*, Ontario.

Leeches (Class Hirudinea) are common ectoparasites of freshwater turtles in North America, but the details of leech-turtle interactions are still being unravelled. In Canada, only two species are known to parasitize turtles: *Placobdella parasitica*, the Smooth Turtle Leech, and *Placobdella ornata*, the Ornate Turtle Leech (Brooks et al. 1990; Galois and Ouellet 2007). However, relatively few studies have been dedicated to leech-turtle interactions, so new records are still common. Turtle leeches can transmit pathogens. For example, both *P. parasitica* and *P. ornata* can transmit the blood parasite *Trypanosoma chrysemidis* between turtles (Siddall and Desser 1992; Woo 1969), and *P. ornata* can transmit the parasite *Haemogregarina balli* to Snapping Turtles (*Chelydra serpentina*) and Painted Turtles (*Chrysemys picta*).

Both *P. parasitica* and *P. ornata* are reported from Blandings Turtles (*Emydoidea blandingii*), Northern Map Turtles, Snapping Turtles and Wood Turtles in Ontario and Quebec (Samure 1990; Samure and Livingstone 1994; Samure and Bider 1996). Brooks et al. (1990) report *P. parasitica* and *P. ornata* from *C. serpentina* in Algonquin Park but found no other species. Brown et al. (1994) also report only *P. parasitica* and *P. ornata* from *C. serpentina*. MacCulloch (1981) and Ricciardi and Lewis (1991) both found *P. parasitica* attached to *C. picta* in Saskatchewan and Quebec, respectively.

Ernst (1976, 1986) reports *P. parasitica* from 12.1% of 207 Spotted Turtles (*Clemmys guttata*), and 38.6% of 204 Stinkpots (*Sternotherus odoratus*); he recorded no other species. *Placobdella parasitica* and *Placobdella ornata* have also been collected from hibernating

Northern Map Turtles in Vermont (Graham et al. 1997). Numerous *P. parasitica* and *P. multilineata* have been collected from Bog Turtles (*Glyptemys muhlenbergii*) in North Carolina and Virginia (Samure and Carter 1998).

In North Carolina ponds, McCoy et al. (2007) observed *P. parasitica* on 4 turtle species (*C. picta*, *C. serpentina*, *Kinosternon rubrum* and *Trachemys scripta*) living in ponds. However, the authors' statement that *P. parasitica* was the only parasitic leech found implies that other leeches not known to be parasitic may have been collected and subsequently discounted. Readell et al. (2008) collected leeches from five species of turtle from ponds in Illinois, including *C. picta*, *C. serpentina*, *Apalone spinifer*, *Sternotherus odoratus* and *Trachemys scripta* (n = approximately 518). They identified the leeches *P. parasitica*, *P. multilineata*, *P. ornata*, *P. papillifera*, and *Helobdella papillata*. Because leeches in the genus *Helobdella* are known to be predatory and feed on invertebrates (Sawyer 1972, 1986), the authors assumed *H. papillata* was not feeding on turtle blood and excluded it from their analysis.

Turtle biologists may often ignore leeches, due partly to the difficulty identifying them to species without a microscope, key and some degree of expertise, as well as the assumption that only two species of leech (*P. ornata* and *P. parasitica*) attach to turtles in Canada. The purpose of this exploratory study was to investigate the diversity and prevalence of leeches on turtles in south-western Ontario and determine whether *P. ornata* and *P. parasitica* were truly the only leeches parasitizing Ontario turtles.



Methods

We collected leeches from turtles from May–August 2008 during an ongoing population study. Turtles were captured by hand, dip net or hoop trap at two sites in south-western Ontario: a wetland on the shores of Lake Erie, Chatham-Kent County, and a spring-fed channel near Lake Huron, Lambton County. Each turtle was identified and checked for leeches. Leeches were removed and placed in 70% ethanol until further examination was possible. We later identified leeches to species using a key modified from Sawyer (1986) by M. Siddall (American Museum of Natural History), available online at <http://research.amnh.org/users/siddall/PEET/sawyer/namerica.html>.

Results

We captured *C. picta*, *C. serpentina*, *E. blandingii*, *C. guttata* and *S. odoratus*, totalling 364 turtle captures representing 296 individuals (some captures were recaptures). Leeches were present on 86 captures (24%). Eleven percent of recaptured Snapping Turtles and 33% of recaptured Painted Turtles had new leeches on them. We collected five leech species: *Placobdella parasitica* and *P. ornata*, which are common on turtles, and *Helobdella modesta*, *Erpobdella punctata* and *Alboglossiphonia heteroclita*, which are not. Table 1 summarizes the turtle species on which each leech species was found, as well as the maximum and minimum number of leeches found on leech-carrying turtles.

We found only one *E. punctata* and one *A. heteroclita*. Considering only the three more common species, 43% percent of leech-carrying turtles were carrying more than one leech, and 9% were carrying more than one species of leech. Leech loads ranged from one to more than 25. Unfortunately, we were occasionally unable to accurately count clusters of very small individuals, for logistical reasons, and it was not always possible to remove every leech from the neck and head of larger *C. serpentina*. It was therefore not possible to collect all observed leeches, but >90% were collected, and all observed leeches were included in estimates of leech loads per individual. Sixteen of the collected leeches were too small or poorly preserved for accurate identification.

Most of the leeches we found were attached to the soft tissue of the legs, neck, and tail base, and this was true for *P. parasitica*, *P. ornata* and *H. modesta*. We did occasionally find leeches on the plastron and carapace, which is not surprising since they are able to feed on the bony tissues of turtles (Siddall and Gaffney 2004). Twenty-two of 25 collected *H. modesta* were carrying either eggs or young.

Discussion

To our knowledge, this is the first published record of *P. ornata* from *C. guttata*, (but see also Samure 1995, unpublished). This is also the first published Canadian record of *Helobdella* species collected from

TABLE 1: Number of turtles carrying one or more of the three observed species of leech at two sites in south-western Ontario. n indicates the number of individual turtles captured; N= total number of captures (including recaptures) of species for which recaptures occurred. Numbers by species indicate the number of turtles carrying that species of leech, with number of that leech species collected in parentheses. Where leeches were carrying eggs or young, the young were not counted separately.

	Turtles with leeches	Leeches on turtles (and max-min number found per leech-carrying turtle)					Other (n=2)	Leech sp. (n=16)
		<i>Placobdella parasitica</i> (n=126)	<i>Placobdella ornata</i> (n=91)	<i>Helobdella modesta</i> (n=25)				
<i>Chrysemys picta</i> (N = 204 n=263)	31	102 (1-25)	14 (48)	2 (2)	1 <i>Alboglossiphonia heteroclita</i>	7 (7)		
<i>Chelydra serpentina</i> (N=78, n=87)	49	121 (1-13)	18 (22)	7 (23)	1 <i>Erpobdella punctata</i>	8 (9)		
<i>Clemmys guttata</i> (N=4)	2	2 (2)	2 (2)	0	-	-		
<i>Emydoidea blandingii</i> (N=7)	5	20 (1-15)	4 (19)	0	-	-		
<i>Stemotherus odoratus</i> (N=3)	1	1 (1)	0	0	-	-		

turtles, and the first record of *H. modesta* (= *H. stagnalis*; see Siddall et al. 2005) collected from turtles on either side of the US-Canada border (but see also Samure 1995\*, unpublished).

Although this also appears to be the first Canadian field record of *P. parasitica* from *Sternotherus odoratus* (Stinkpot), this is likely the unidentified species collected from Stinkpots by Edmond and Brooks (1996). We suspect these leeches have all been observed on these turtle species numerous times, and have simply not been identified to species.

We find the repeated occurrence of *Helobdella modesta* on *C. picta* and *C. serpentina* to be of particular interest. *Helobdella papillata* has been recorded from turtles (Readel et al. 2008), but these leeches were excluded from that study's analyses based on the assumption that they do not feed on turtle blood. As members of the genus *Helobdella* are predators of invertebrates (Sawyer 1986), this was a reasonable assumption. However, we also found *Helobdella* on turtles. While it is impossible to say whether they were blood-feeding at this time (a confirmation study is in progress), their presence does not appear to be a random or accidental record. In any case, we consider it unlikely that a leech would repeatedly attach itself to a turtle (or any other substrate) purely accidentally. Leeches have keen chemosensory abilities, and most species are fully capable of free-swimming to reach their preferred destination (Sawyer 1986). An exception may be *H. modesta* which is not a strong swimmer, so dispersal cannot be ruled out as a benefit of attaching to turtles.

The relationship between freshwater turtles and leeches of the genus *Helobdella* requires further close investigation. Although *Helobdella* may in fact be parasitizing these species of turtles, their recurring presence may also be due to several additional factors. *Helobdella* species may gain some non-nutritional benefit from attaching to turtles. For example, Sawyer (1972) suggests that attachment to larger hosts could provide leeches with a mechanism for fast dispersal with minimum energy expenditure. Attaching to turtles might also provide access to *H. modesta*'s invertebrate prey, including other leeches.

We also considered the possibility that attachment to a turtle might provide protection from predation – but Krawchuck et al. (1997) documented a potential cleaning symbiosis in which a *C. picta* ate leeches from the skin of *C. serpentina*, and a similar relationship was documented once between Map Turtles and Grackles (Vogt 1979). These observations suggest that hitchhiking could be a risky behaviour for a leech, unless some strong benefit outweighed the risk.

Lastly, we know of no biological reason why *Helobdella* should be unable to feed on turtles. Analyses of the gut contents of *Helobdella* collected from turtles (in progress) will hopefully confirm or discount this possibility. Whether they are feeding on turtle blood

or are merely hitching a ride, we suspect that there is more to their behaviour than random chance. Even though *P. parasitica* and *P. ornata* are clearly the most common parasites of turtles in Ontario (and possibly in eastern North America), the behaviour of other leech species (especially *Helobdella* spp.) deserves more investigation before their potential role as turtle parasites can be discounted.

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# Annual and Monthly Variation in Species Composition and Catches of Fishes from the Tabusintac River Estuary in the Southern Gulf of St. Lawrence

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A total of 7130 fish from 13 taxa were collected during summer and autumn, 2002–2005 using box traps at two sites in the Tabusintac River Estuary, New Brunswick, Canada. The objective was to determine seasonal change in species composition and catches, and to access change in annual returns of Atlantic Salmon, an important recreational fishery during autumn on the Tabusintac, Miramichi and neighboring rivers. Taxa richness and composition varied annually and from trap to trap. Richness ranged from 8–10 taxa annually and catches were usually highest in the trap closest to the ocean despite its slightly smaller size. Taxa contributing greater than one percent of the total catch during the four years of sampling included six diadromous taxa: Blueback Herring and Alewife (41.65%), Striped Bass (21.54%), Atlantic Salmon (3.98%), Tomcod (2.95%), Brook Trout (1.05%), American Eel (5.27%); one freshwater species, White Sucker (11.96%); one marine species, Winter Flounder and one resident estuarine species, Smooth Flounder which together account for 11.19% of the total catch. The remaining five species (American Smelt, Northern Pipefish, White Perch, Cunner, Sea Lamprey) contributed 0.39% of the total catch. The fish fauna 14–15 km up the Tabusintac River was not species rich, due in large part to the limited sampling time each year and due to fishing with just one sampling gear, a stationary box trap. Additional species would have been collected if smaller mesh sampling gear were used. Comparisons were made with other studies and the phenology of the dominant species on the Tabusintac and Miramichi River Estuaries during the ice free season is established. Most catches appear to be related to pre- or post-spawning movements of anadromous fishes.

Key Words: Atlantic Salmon, *Salmo salar*, anadromous fishes, migration, Tabusintac River Estuary, New Brunswick.

Canada has a relatively depauperate freshwater fish fauna, despite having a surface area of almost 10 million km<sup>2</sup> and five extensive drainage basins that include several northern and Great Lakes (>25,000 km<sup>2</sup>) and many long rivers. The freshwater fish fauna consist of approximately 24 families containing less than 200 species (Scott and Crossman 1998). Five families Salmonidae, Catostomidae, Cyprinidae, Percidae, and Cottidae account for 70% of the fauna (Scott and Crossman 1998). Species richness is highest (>100 species) in central Canada and lowest on Prince Edward Island and insular Newfoundland (20–25 species; Scott and Crossman 1998; Taylor 2004; Curry 2007). This low diversity relates to Canada's northern position and to extensive ice coverage during the Pleistocene.

The low richness of eastern Canada's freshwater fish fauna and the low richness of north temperate estuaries in general (Haedrich 1983; Sosa-Lopez and Mouillot 2007) suggest that catches of riverine and estuarine fishes in eastern Canada should be dominated by relatively few species. Fish assemblages in estuaries of Atlantic Canada are poorly studied despite the well known importance of estuaries as nursery and feeding grounds, and as places of exceptionally high productivity (Haedrich 1983). Numerous studies have been conducted on individual species but fish communities

as a whole are described in only a handful of studies in Atlantic Canada. Of note are studies by McKenzie (1959), Chaput (1995), and Hanson and Courtenay (1995) who report on species composition and relative abundance of fishes in the Miramichi River and Estuary (c. 300 km<sup>2</sup>) in the southern Gulf of St. Lawrence. A total of 78 species were collected in the Miramichi River, its estuary and nearby marine waters (McKenzie 1959; Hanson and Courtenay 1995). This contrasts with 23 species collected in a more northerly, and much smaller estuary (<10 km<sup>2</sup>) at Bellevue Newfoundland that was sampled throughout the year at a single site (Methven et al. 2001).

Variability in species richness, composition and abundance of fishes in estuaries is related to several small and large scale spatial factors that include latitude, size of the estuary, and the location and number of habitats sampled (Haedrich 1983; Sosa-Lopez and Mouillot 2007). Temporal variability also has a significant bearing on species richness, composition, and abundance of fishes taken in estuaries and other coastal habitats. Temporal variation is assumed to be concentrated at periodic scales, e.g. tidal, diel, lunar, seasonal and annual (Laevastu and Hayes 1981), with numerous studies reporting high contrasts in catches and species richness of estuarine and coastal marine fishes at these



scales (Dahlberg and Odum 1970; Gibson et al. 1996; Lazzari et al. 1999; Methven et al. 2001; deBruyn and Meeuwig 2001).

In this study we describe annual variation in species composition, catches and size structure of the dominant fishes taken in two stationary traps located 14–15 km up the Tabusintac River in the southern Gulf of St. Lawrence during summer and autumn, 2002–2005. We integrate our findings with previous studies and establish the phenology of the dominant species during the ice free season. The Tabusintac River Estuary is located less than 30 km from the much larger Miramichi Estuary. Together, these two estuaries contribute significantly to local commercial and recreational fisheries (McKenzie 1959; Chaput 1995; Comeau 2001a), an observation that is made repeatedly for estuarine based fisheries throughout the world (McHugh 1976; Pollard 1981; Haedrich 1983). Species in the commercial and recreational fisheries in the Tabusintac and Miramichi Rivers include Gaspereau (*Alosa* spp), American Eel (*Anguilla rostrata*), Atlantic Salmon (*Salmo salar*), American Smelt (*Osmerus mordax*), Tomcod (*Microgadus tomcod*) and Brook Trout (*Salvelinus fontinalis*) (McKenzie 1959; Chaput 1995; Comeau 2001a, 2001b).

## Methods

All sampling was confined to the Tabusintac River Estuary in New Brunswick, Canada. The Tabusintac River drains into Tabusintac Bay in the southern Gulf of St. Lawrence. The river has more than 34 tributaries and a drainage area of 717 km<sup>2</sup> (Comeau 2001a). The Tabusintac River, located just north of the Miramichi River, freezes over each year usually from December to April (Chaput 1995).

### Study sites

Two study sites (designated MT [47°20.283'N, 65°06.828'W] and RT [47°20.098'N, 65°07.948'W]) were located on the main branch of the Tabusintac River. The MT site was located on the south side of the river in an area of low water flow with a substratum of small rocks nearshore, and mud in the central channel. The Tabusintac River measures approximately 160 meters wide and 4–5 meters deep at low tide at the MT site. The RT site was located 1.5 km further upstream on the north side of the river. The sites share similar habitat characteristics and a tidal amplitude of approximately 0.6–0.8 meters. Refer to Comeau (2001b) for additional information on the location of the two box traps (described below) in the Tabusintac River.

### Trap description

Fish were collected in Y shaped box traps from 2002–2004 and T shaped box traps in 2005. One trap was located at each sampling site. Traps were secured by wooden pickets and brace work and were rectangular in shape with a short side to long side ratio of at least 1:4 (Dunfield 1974). The Y trap at the MT site

measured 14.96 × 3.67 meters (50 mm stretch mesh) and had two leaders of different lengths (30.48 and 45.72 m), both with 71 mm stretch mesh. The Y trap at the RT site was slightly larger 15.26 × 3.67 m (50 mm stretch mesh) and also had two leaders (30.48 and 45.72 m) both with 139 mm stretched mesh. Both T traps (2005) measured 18.90 × 3.35 meters (50 mm stretched mesh) and had a single 45.72 meter long leader with 47 mm stretched mesh. Y and T traps were located at the same sites each year (to within approximately five m) in approximately two meters of water at low tide. Traps were located approximately 46 meters from the shore each year. Initial formation of ice at both sites resulted in the traps being removed from the water by early November.

### Fish collections

Fish were collected in both traps from late July to early November. However, dates of sampling varied among years (Table 1). Traps were sampled between 08:00–10:00 hrs each day except on days when winds were too high to safely travel by boat or on days when traps were being repaired and cleaned. The number of days that the traps were not sampled each year is given in Table 1 as the difference between total days that traps were in the water and sample days, i.e., the number of days the traps were checked (Table 1). For example, traps were not checked for two days in 2002 (Table 1). Water temperature was taken in 2002 using a VEMCO 8-bit Minilog-TR that recorded once daily at approximately 30 cm depth. Water temperature was taken daily using a hand held alcohol thermometer at approximately 30 cm below the surface in 2003–2005.

Fish were identified to species with the exception of *Alosa pseudoharengus* – *A. aestivalis* and *Pseudopleuronectes americanus* – *Pleuronectes putnami*. Both species of *Alosa* were tentatively, but not routinely identified beginning in 2001. We refer to the combined catches of these two species as *Alosa* spp. We investigated if we were catching both *Pseudopleuronectes americanus* (Winter Flounder) and *Pleuronectes putnami* (Smooth Flounder) by examining several collections taken in September and October 2007 ( $n=30$  specimens). Both species were present in the collections we examined in 2007 (19 *Pseudopleuronectes americanus*; 11 *Pleuronectes putnami*) and we conclude that both species were very likely present in 2002–2005. The 30 specimens of *Pseudopleuronectes americanus* (12.2–22.4 cm) and *Pleuronectes putnami* (13.6–27.7 cm) were deposited in the New Brunswick Museum in Saint John (NBM Catalogue Numbers 2256–2277). These species were distinguished using anal finray counts (Collette and Klein-MacPhee 2002), a character that did not overlap for the 30 specimens we examined (Winter Flounder: range 42–49, mean 46.4; Smooth Flounder: range 36–41, mean 37.7). Mature male Atlantic Salmon were separated from females by the presence of a kype, a distinctive hooked jaw that males develop during spawning (Scott and Scott 1988). All *Morone saxatilis*,

TABLE 1. Dates, duration (total days) and number of sampling days for each trap (MT, RT) on the Tabusintac River 2002 to 2005.

Year	Trap	Dates	Total days	Sample days
2002	MT	19 September – 8 November	51	49
	RT	19 September – 8 November	51	49
2003	MT	22 July – 26 October	97	90
	RT	22 July – 26 October	97	90
2004	MT	21 July – 26 September	68	62
	RT	21 July – 26 September	68	62
2005	MT	4 August – 10 October	68	64
	RT	12 August – 11 October	61	57

*Salmo salar* and *Anguilla rostrata* were measured to the nearest 0.5 cm Fork Length (Total Length [TL] for *Anguilla rostrata*). All fish taken during this study were returned to the water alive except 41 *Salmo salar* and one *Alosa* spp. that were harvested as part of the Burnt Church First Nation food fishery.

Data are summarized in Table 2 by presenting total number of fish caught for each species in each trap (MT, RT) for each year (2002 to 2005). Number of sampling days was consistent within each year for the MT and RT traps except in 2005 (Table 1). Taxa richness was determined based on the number of individual species (or taxa) taken in each trap (Table 2). For example, richness was 10 taxa for the MT trap in 2002, two of which had the same rank abundance (Table 2).

## Results

Overall, a total of 7130 fish from 13 taxa were caught during the four years of sampling (Table 2). Taxa richness ranged from 8–10 depending on the trap and year of sampling (Table 2). The maximum difference in taxa richness between the MT and RT traps in any given year was two (Table 2). Total catch and taxa richness were consistently higher at the MT site located closest to the ocean (Table 2) despite this trap being slightly smaller in size. Fishes captured in both traps during the four years of sampling in decreasing order of catch included (Table 2): *Alosa* spp. (41.65%), *M. saxatilis* (21.54%), *C. commersoni* (11.96%), *Pseudopleuronectes americanus* – *Pleuronectes putnami* (11.19%), *A. rostrata* (5.27%), *S. salar* (3.98%), *M. tomcod* (2.95%) and *S. fontinalis* (1.05%). The remaining species (*Osmerus mordax*  $n=2$ ; *Syngnathus fuscus*  $n=1$ ; *Petromyzon marinus*  $n=2$ ; *Morone americana*  $n=22$ ; *Tautoglabrus adspersus*  $n=1$ ) contributed only 0.39% of the total catch. In addition, sticklebacks (Gasterosteidae) were also observed but seldom retained in the mesh of the traps. Several non-fish species were also collected: one Beaver (*Castor canadensis*, 2003 RT) was dead when found, one Cormorant (*Phalacrocorax* spp., 2004 MT) that died, 16 Red Breasted Mergansers (*Mergus serrator*, 2004 RT  $n=11$ ; 2005

MT  $n=5$ , no mortality) plus numerous jellyfish of the genera *Aurelia* and *Cyanea*.

Some of the annual variation in taxa richness and total catch was due to the different dates of trap deployment and retrieval each year (Table 1). When data were standardized (i.e., examined for the common days sampled in 2003–2005 (46 days: 12 August to 26 September), the five most abundant taxa taken in the MT trap were (Table 2): *M. saxatilis* (31.37%), *Alosa* spp. (26.38%), *Pseudopleuronectes americanus* – *Pleuronectes putnami* (19.29%), *C. commersoni* (17.23%) and *A. rostrata* (2.51%). This ranking is generally similar to the RT trap over the same time period (Table 2): *M. saxatilis* (50.70%), *Alosa* spp. (16.32%), *C. commersoni* (12.81%), *Pseudopleuronectes americanus* – *Pleuronectes putnami* (8.07%) and *S. salar* (4.56%). 2002 was not included in this comparison (of common days) because there was only eight days of sampling in 2002 that overlapped with sampling in 2003–2005. Taxa richness and total catch were still highest in the MT trap when data were examined for the 46 common days of sampling (Table 2) indicating richness and total catch increase when sampling towards the ocean.

Little variation in water temperature was observed between the two traps on any given day of sampling despite the traps being 1.5 km apart. Hence annual correlations ( $r$ ) of daily water temperatures were high (2002: 0.987; 2003: 0.964; 2004: 0.959; 2005: 0.999). Mean water temperatures were essentially identical when calculated for the 46 common days of sampling each year (2003: MT 17.7°C, RT 17.4°C; 2004: MT 19.5°C, RT 19.3°C; 2005: MT 19.6°C, RT 19.6°C). Water temperature was generally highest in late July and early August (c. 23°C) and declined rapidly from mid September (c. 18°C) to late October (c. 5°C) (Figure 1). Throughout the course of study (21 July to 8 November, 2002–2005) water temperature ranged from a low of 0.2°C (RT, 20 October 2002) to a high of 27°C (MT, 5 August 2004).

Field notes were kept on species marked by Sea Lamprey, *Petromyzon marinus*, as evidenced by a char-



TABLE 2. Number of fish caught in each trap (MT, RT), percentage abundance (%) and species rank (based on percent abundance) for all days of sampling 2002 to 2005 (top), and for days that the traps fished in common (12 August to 26 September) in 2003 to 2005 (bottom). Totals refer to the total catch and the number of taxa taken in each trap and year.

Genus species (Common name)	2002						2003						2004						2005					
	MT	%	Rank	RT	%	Rank	MT	%	Rank	RT	%	Rank	MT	%	Rank	RT	%	Rank	MT	%	Rank	RT	%	Rank
<i>Morone saxatilis</i> (Striped Bass)	137	24.95	1	108	49.32	1	193	9.82	4	120	21.24	2	523	25.51	2	138	24.00	2	161	19.17	2	156	42.51	1
<i>P. americanus</i> , <i>P. putnami</i> (Flounders)	93	16.94	2	3	1.37	7	319	16.23	3	28	4.96	5	271	13.22	3	30	5.22	4	49	5.83	5	5	1.36	7
<i>Salmo salar</i> (Atlantic Salmon)	74	13.48	3	39	17.81	2	46	2.34	7	23	4.07	6	32	1.56	4	22	3.83	5	17	2.02	7	31	8.45	3
<i>Catostomus commersoni</i> (White Sucker)	73	13.30	4	1	0.46	8	399	20.31	2	45	7.96	3	30	1.46	5	40	6.96	3	136	16.19	3	129	35.15	2
<i>Anguilla rostrata</i> (American Eel)	55	10.02	5	12	5.48	5	107	5.45	5	17	3.01	7	18	0.88	6	16	2.78	6	132	15.71	4	19	5.18	4
<i>Alosa</i> spp. (Herring Family)	52	9.47	6	30	13.70	3	795	40.46	1	284	50.27	1	1163	56.73	1	319	55.48	1	310	36.90	1	17	4.63	5
<i>Microgadus tomcod</i> (Atlantic Tomcod)	35	6.38	7	12	5.48	5	82	4.17	6	33	5.84	4	5	0.24	8	7	1.22	7	28	3.33	6	8	2.18	6
<i>Salvelinus fontinalis</i> (Brook Trout)	28	5.10	8	14	6.39	4	10	0.51	9	9	1.59	8	6	0.29	7	2	0.35	8	5	0.60	8	1	0.27	8
<i>Osmerus mordax</i> (American Smelt)	1	0.18	9	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
<i>Syngnathus fuscus</i> (Northern Pipefish)	1	0.18	9	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
<i>Morone americana</i> (White Perch)	0	0.00		0	0.00		13	0.66	8	5	0.88	9	2	0.10	9	1	0.17	9	1	0.12	9	0	0.00	
<i>Tautoglabrus adspersus</i> (Cunner)*	0	0.00		0	0.00		1	0.05	10	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
<i>Petromyzon marinus</i> (Sea Lamprey)	0	0.00		0	0.00		0	0.00		1	0.18	10	0	0.00		0	0.00		1	0.12	9	0	0.00	
Totals	549		10	219		8	1965		10	565		10	2050		9	575		9	840		10	367		9

Genus species (Common name)	2003						2004						2005						2005					
	MT	%	Rank	RT	%	Rank	MT	%	Rank	RT	%	Rank	MT	%	Rank	RT	%	Rank	MT	%	Rank	RT	%	Rank
<i>Alosa</i> spp. (Herring family)	168	18.56	3	29	21.64	3	162	16.58	3	47	18.15	2	310	56.99	1	17	9.60	2	310	56.99	1	17	9.60	2
<i>Catostomus commersoni</i> (White Sucker)	388	42.87	1	33	24.63	2	29	2.97	5	39	15.06	3	1	0.18	7	1	0.56	6	1	0.18	7	1	0.56	6
<i>Salmo salar</i> (Atlantic Salmon)	4	0.44	7	0	0.0		31	3.17	4	20	7.72	5	6	1.10	6	6	3.39	3	6	1.10	6	6	3.39	3
<i>P. americanus</i> , <i>P. putnami</i> (Flounders)	212	23.43	2	19	14.18	4	215	22.01	2	25	9.65	4	41	7.54	3	2	1.13	5	41	7.54	3	2	1.13	5
<i>Anguilla rostrata</i> (American Eel)	27	2.98	5	4	2.99	6	17	1.74	6	15	5.79	6	17	3.13	4	4	2.26	4	17	3.13	4	4	2.26	4
<i>Microgadus tomcod</i> (Atlantic Tomcod)	12	1.33	6	10	7.46	5	5	0.51	7	5	1.93	7	10	1.84	5	1	0.56	6	10	1.84	5	1	0.56	6
<i>Morone saxatilis</i> (Striped Bass)	90	9.94	4	38	28.36	1	513	52.51	1	105	40.54	1	158	29.04	2	146	82.49	1	158	29.04	2	146	82.49	1
<i>Salvelinus fontinalis</i> (Brook Trout)	1	0.11	9	1	0.75	7	3	0.31	8	2	0.77	8	0	0.00		0	0.00		0	0.00		0	0.00	
<i>Morone americana</i> (White Perch)	1	0.11	9	0	0.00		2	0.20	9	1	0.39	9	0	0.00		0	0.00		0	0.00		0	0.00	
<i>Tautoglabrus adspersus</i> (Cunner)*	2	0.22	8	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
<i>Petromyzon marinus</i> (Sea Lamprey)	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		1	0.18	7	0	0.00	
Totals	905		10	134		7	977		9	259		9	544		8	177		7	544		8	177		7

\*identification tentative

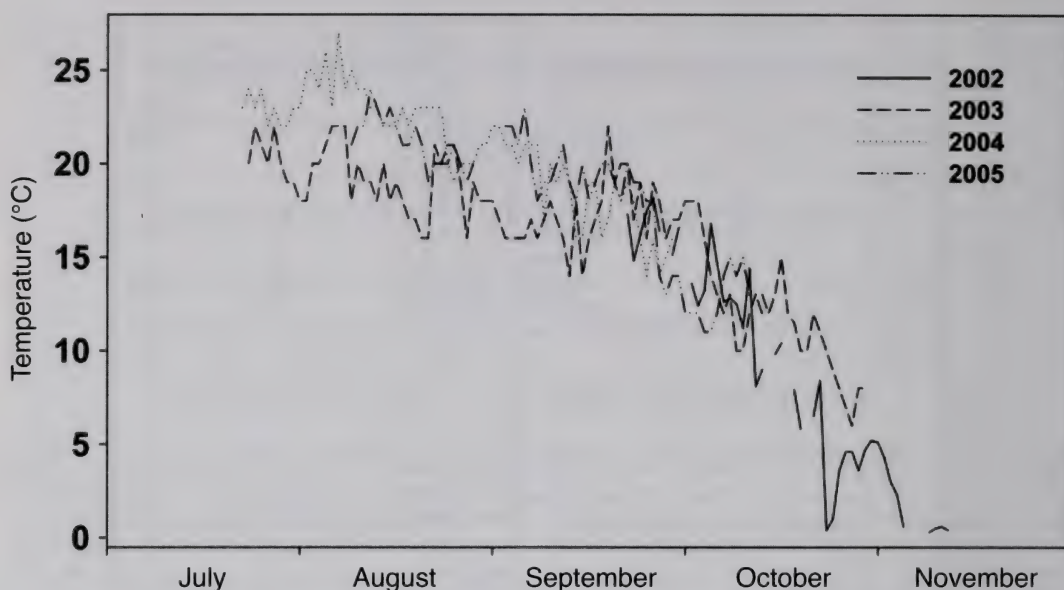


FIGURE 1. Variability in daily water temperatures ( $^{\circ}\text{C}$ ) taken 30 cm below the surface at the MT site in the Tabusintac River 2002-2005.

acteristic circular wound due to rasping of scales and flesh with the lingual teeth of their sucker like mouths. Two species, *M. tomcod* ( $n=2$  fish in 2003, one with one mark on the caudal peduncle, the other with two marks on the lower body) and *A. rostrata* ( $n=2$ , 2004, 2005; one with a mark on its head and the other with a mark on its back) were observed with Sea Lamprey wounds. Only one Sea Lamprey was caught in the traps during the four years of study (13 August 2005 MT, 65 cm). This Sea Lamprey may have been knocked off its host when the trap was hauled.

The two *Alosa* species (*Alosa pseudoharengus*, *A. aestivalis*; Alewife, Blueback) were not consistently distinguished from each other in our study. Together these two species accounted for 41.65% of the total catch (2002-2005, Table 2). *Alosa* spp. were caught throughout the sampling period with highest catches in mid July and early August at water temperatures of  $\sim 18\text{--}24^{\circ}\text{C}$  (Figure 2). *Alosa* spp. were occasionally caught at temperatures as low as  $5^{\circ}\text{C}$  in 2002. Highest temperature of capture was  $27^{\circ}\text{C}$  but few fish were caught at temperatures greater than  $25^{\circ}\text{C}$ . *Alosa* spp. were not measured, but most fish were approximately 25 cm FL.

*Morone saxatilis* was the second most abundant species taken during the four years of overall sampling (21.54%, Table 2). It was the dominant species taken at both the MT (31.37%) and RT (50.70%) sites when data were examined from 12 August to 26 September (Table 2). Catches of *Morone saxatilis* were highest at the RT site for each of the standardized col-

lections (Table 2). *Morone saxatilis* was taken each year throughout the sampling period with highest catches from September to November as water temperature declined (Figure 3). *Morone saxatilis* was predominantly caught at water temperatures between  $10\text{--}25^{\circ}\text{C}$  (2003-2005) but was taken at temperatures as low as  $0.2^{\circ}\text{C}$  in late October 2002 (Figure 3). Lengths of *Morone saxatilis* ranged overall from 5.0-81.9 cm FL there being three size modes present at approximately 10-15, 25-35 and 45-65 cm FL (Figure 4).

Catches of *C. commersoni* ranked it as the third dominant species overall (11.96%, Table 2) but when data were standardized and compared for the common days of sampling (2003-2005) it ranked fourth (16.39%, Table 2). Ranking ranged from first in 2003 (MT) to seventh in 2005 (MT). At times, this species could be very abundant with catches exceeding 100 fish (per trap per day) on two occasions (2003 MT, Figure 5). *Catostomus commersoni* was most abundant from late August to early October at water temperatures of  $10\text{--}20^{\circ}\text{C}$ . Timing of peak catches varied considerably from year to year (Figure 5).

The two flatfishes, *Pseudopleuronectes americanus* and *Pleuronectes putnami* ranked as the fourth dominant taxa overall, (11.19%, Table 2) and ranked third (17.16%, Table 2) when examined from 12 August to 26 September 2003-2005. Catches were consistently much higher at the MT site (Table 2). Catches were relatively constant throughout the sampling period but could be punctuated and occasionally exceeded 20 fish per trap-day in late July and late August (Fig-



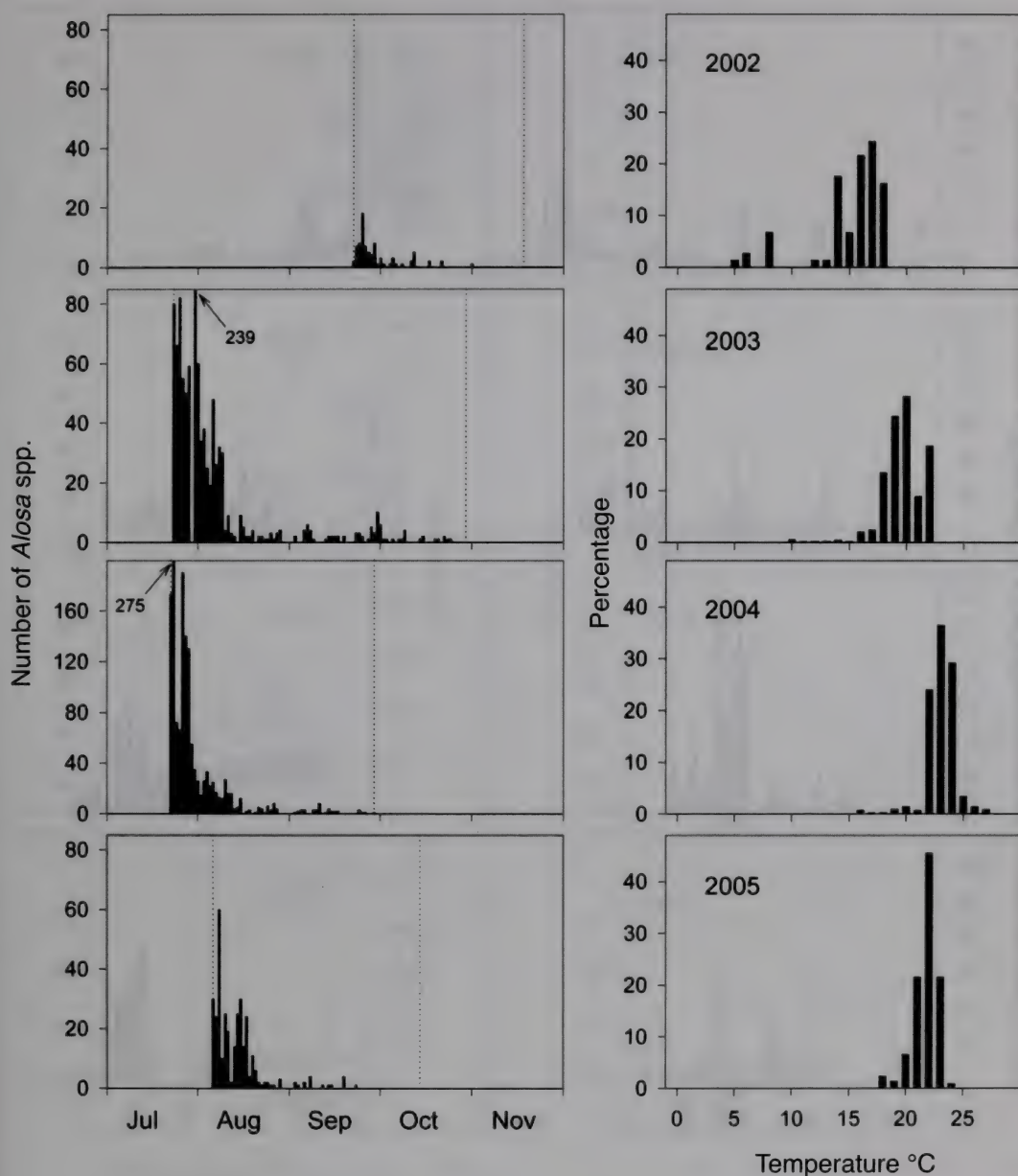


FIGURE 2. Daily catches of Blueback Herring and Alewife (*Alosa* spp.) from the combined catches of both traps (MT + RT) in the Tabusintac River 2002-2005. Dotted vertical lines represent the beginning and end of sampling. Right side panels show catches (as percent) in relation to temperature.

ure 6). Catches were highest at temperatures between 8-20°C but these species were caught at a broad range of temperatures from 0.4-27°C (Figure 6).

*Anguilla rostrata* had an overall rank of five (5.27%, Table 2) and also ranked fifth (2.80%, Table 2) when common days of sampling were compared among

years (2003-2005). Catches were highest in October at water temperatures of approximately 10-20°C (Figure 7). It is difficult to identify size modes given that most *A. rostrata* were from 55-80 cm TL with very few caught at sizes less than 40 cm (Figure 8). There is no evidence of growth as indicated by increase in

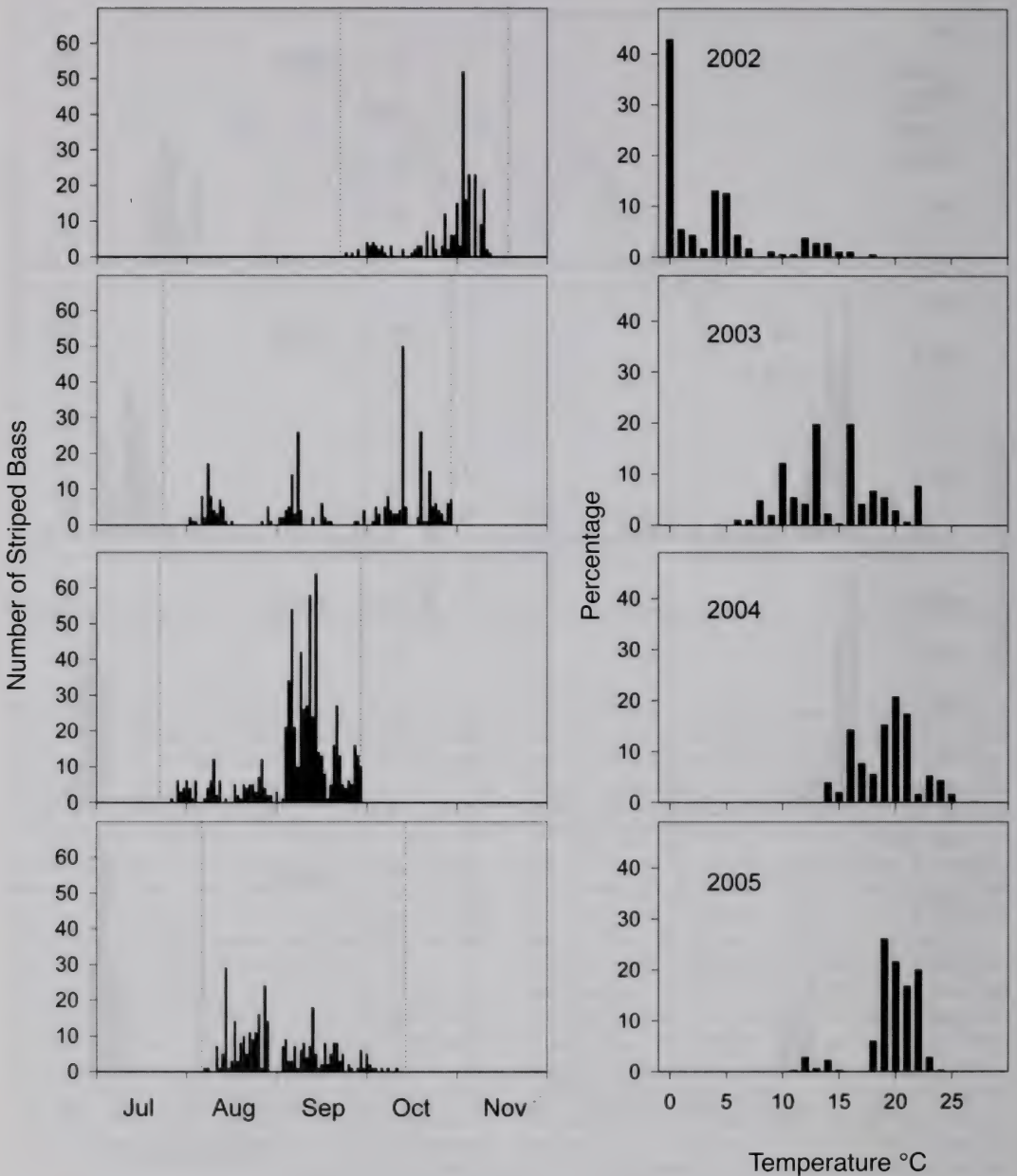


FIGURE 3. Daily catches of Striped Bass (*Morone saxatilis*) from the combined catches of both traps (MT + RT) in the Tabusintac River 2002-2005. Dotted vertical lines represent the beginning and end of sampling. Right side panels show catches (as percent) in relation to temperature.

modal sizes in any of the years examined (Figure 8). Activity is reported to be highest at night when feeding is thought to occur (Hanson and Courtenay 1995) and when movement is apparently stimulated by rainfall (Collette and Klein-MacPhee 2002). Our highest catch (2 October 2005, n=23, MT; Figure 7)

occurred during a rain-free period from 28 September to 7 October 2005.

*Salmo salar* ranked sixth overall (3.98%, Table 2) and maintained the same rank when years were compared for common days of sampling from 12 August to 26 September (2.24%, 2003-2005, Table 2). Catch-



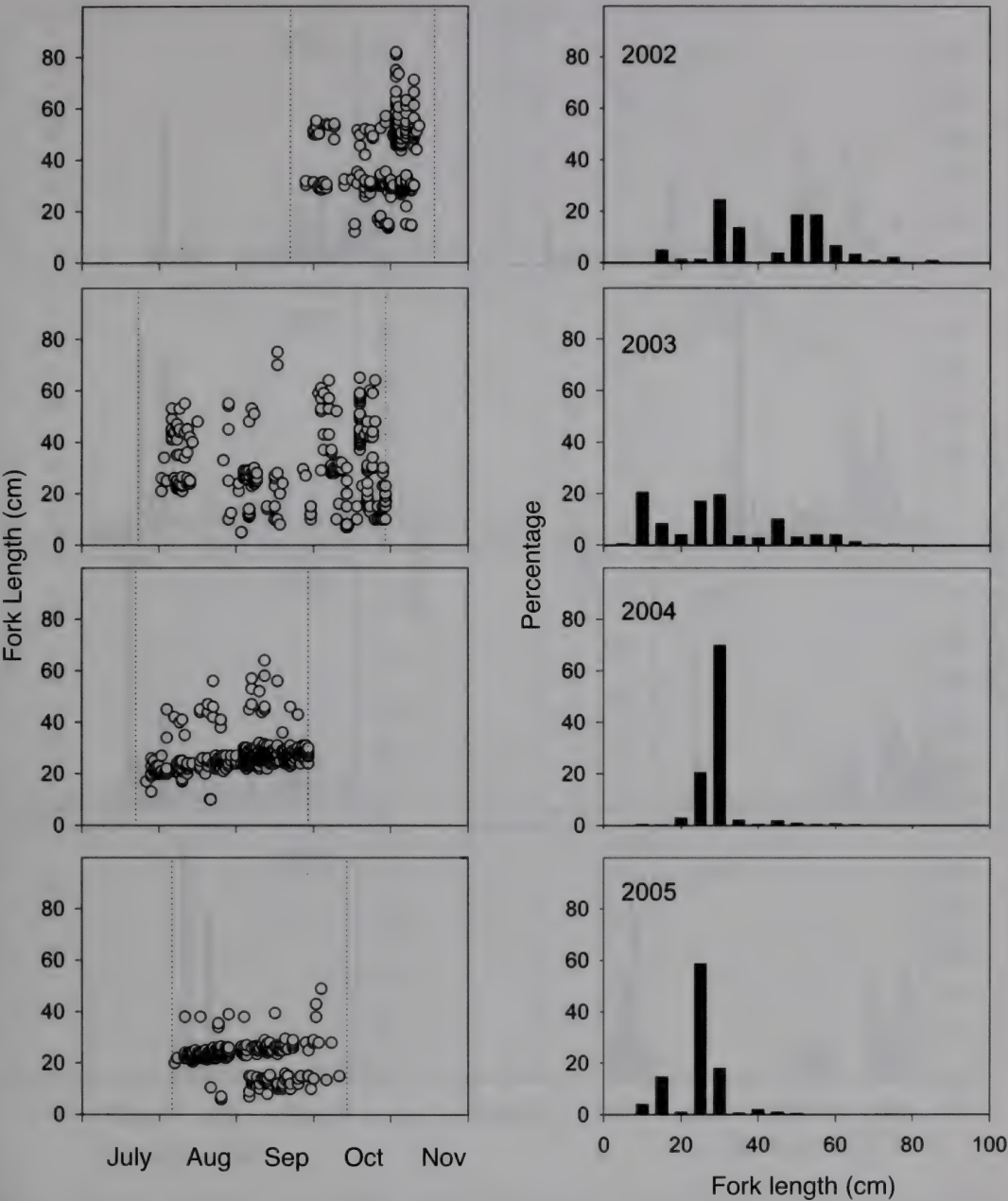


FIGURE 4. Daily lengths of individual Striped Bass (*Morone saxatilis*) and length frequencies (as percent) calculated from both traps combined (MT + RT) in the Tabusintac River 2002-2005. Dotted vertical lines represent the beginning and end of sampling.

es were highest in late September and throughout October at water temperatures of 5-17°C (Figure 9). *Salmo salar* were caught at temperatures as low as 0.4°C and as high as 25°C (Figure 9). Catches never exceeded 8 fish in a trap on any given day (Figure 9). When all data are examined, catches declined from 2002 to 2005 (Table 2). However, catches showed no consistent increasing or decreasing trend when the data were standardized (12 August to 26 September) and compared among years (2003:  $n=4$ ; 2004:  $n=23$ ; 2005:  $n=12$ ). Catches were highest at the MT site in all years except 2005 (Table 2). Three size modes were

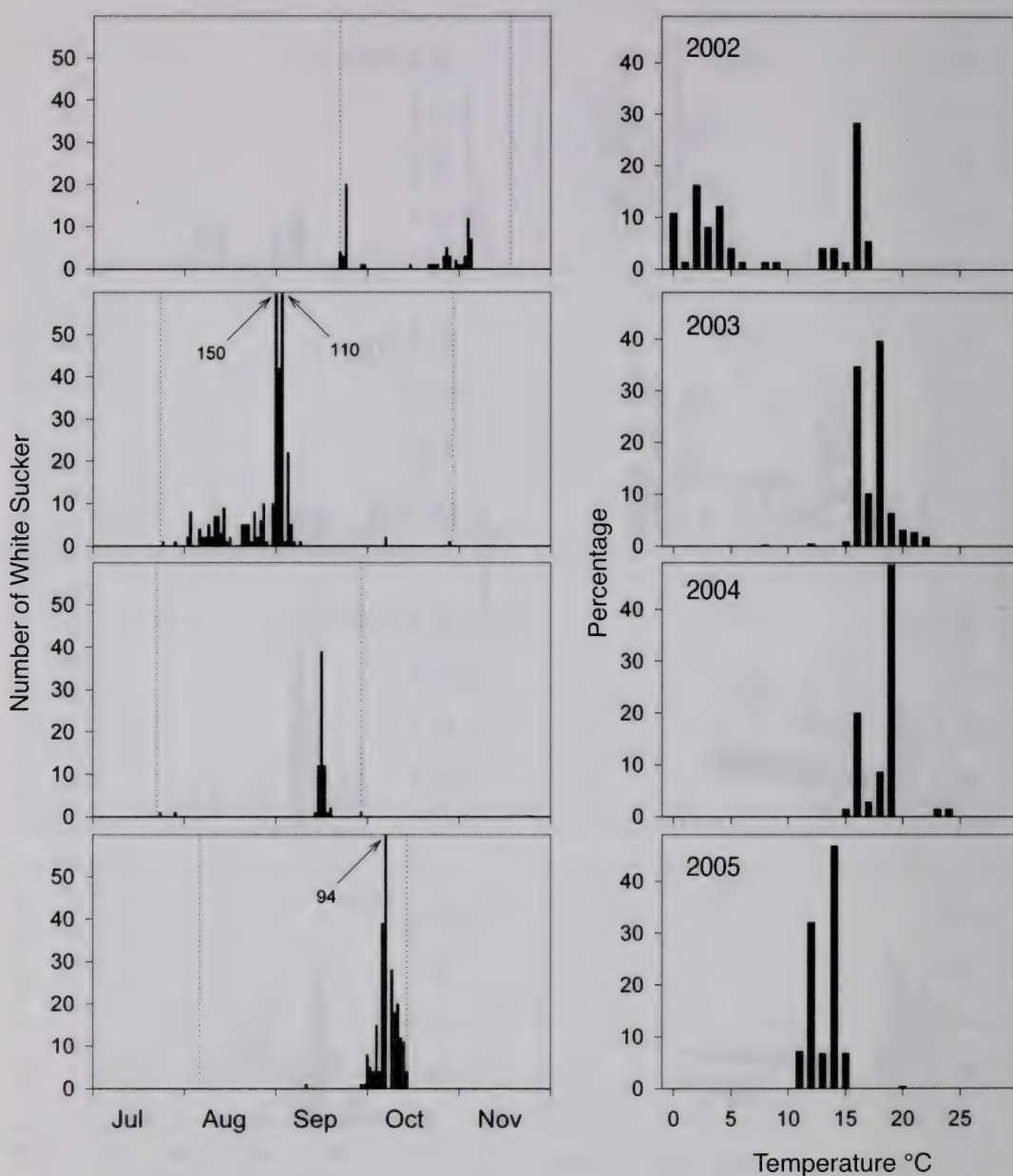


FIGURE 5. Daily catches of White Sucker (*Catostomus commersoni*) from the combined catches of both traps (MT + RT) in the Tabusintac River 2002-2005. Dotted vertical lines represent the beginning and end of sampling. Right side panels show catches (as percent) in relation to temperature.

observed at approximately 55-65, 75-85 and 95-105 cm FL (Figure 10). The smallest mode 55-65 cm FL, consisted overwhelming of males (96.8%) with females dominating the two larger modes (68.95%) (Figure 10).

Overall *M. tomcod* was ranked seventh, a rank that it retained when the data were standardized (12 August to 26 September, 2003-2005) and compared among

years (Table 2). Catches were highest at the MT site in all years except in 2004 (Table 2). Catches were highest in September and October at temperatures of 5-19°C although it was most abundant in 2002 (the year with the latest date of sampling) at temperatures less than 5°C (Figure 11).



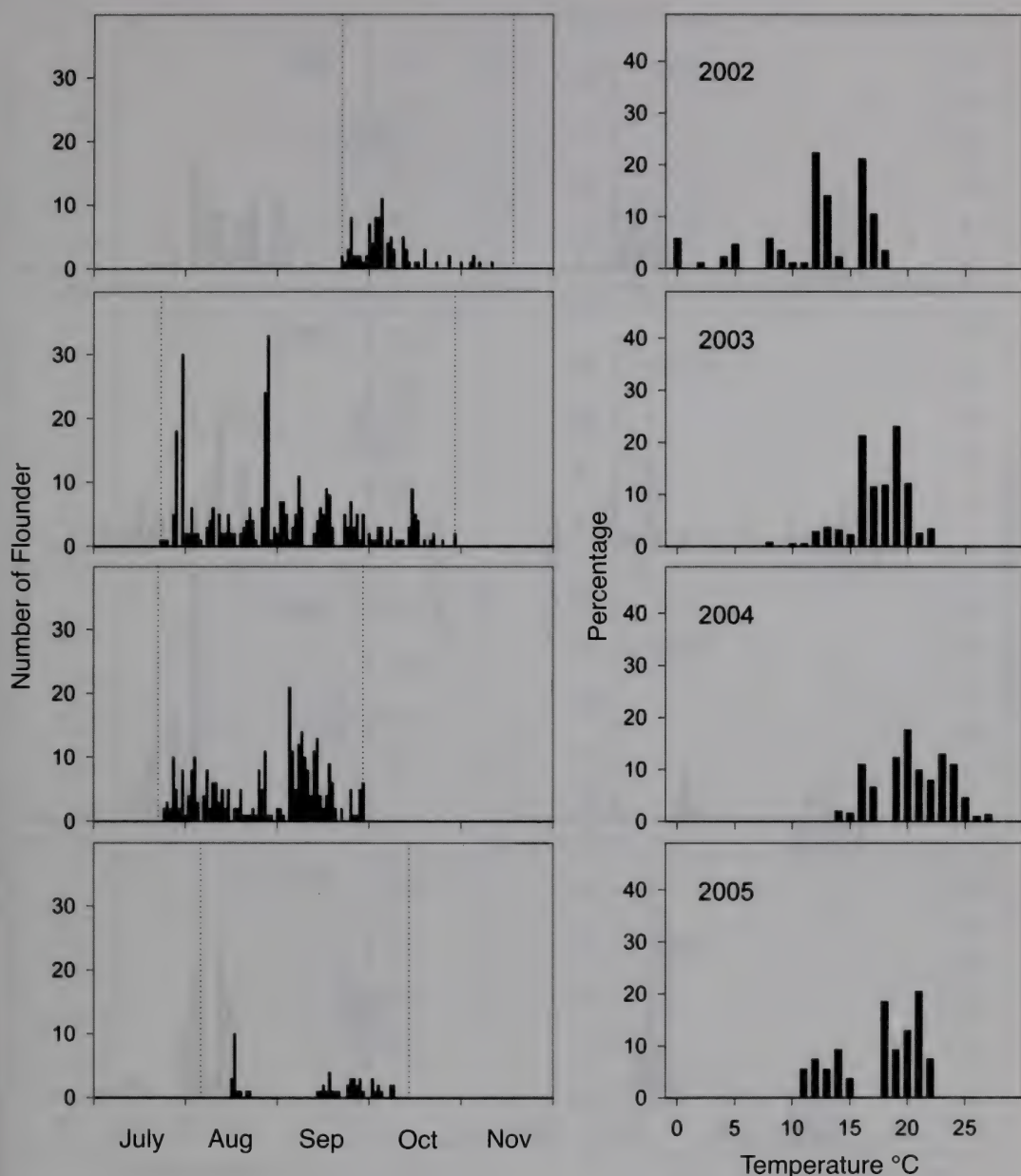


FIGURE 6. Daily catches of Winter Flounder (*Pseudopleuronectes americanus*) and Smooth Flounder (*Pleuronectes putnami*) from the combined catches of both traps (MT + RT) in the Tabusintac River 2002-2005. Dotted vertical lines represent the beginning and end of sampling. Right side panels show catches (as percent) in relation to temperature.

## Discussion

The fish fauna of the Tabusintac River Estuary fit nicely within McHugh's (1967) six ecological categories of estuarine fishes. Of the dominant taxa sampled, *C. commersoni* was the only freshwater species taken. *Pseudopleuronectes americanus* was the only marine species and *Pleuronectes putnami* was the only

estuarine species caught. *Pleuronectes putnami* moves seasonally within the Miramichi River and estuary, a large estuary approximately 30 km south of the Tabusintac River, where it apparently lives its entire life (Hanson and Courtenay 1997). *Pleuronectes putnami* may occur in slightly deeper coastal water in the Gulf of Maine (Collette and Klein-MacPhee 2002). The six

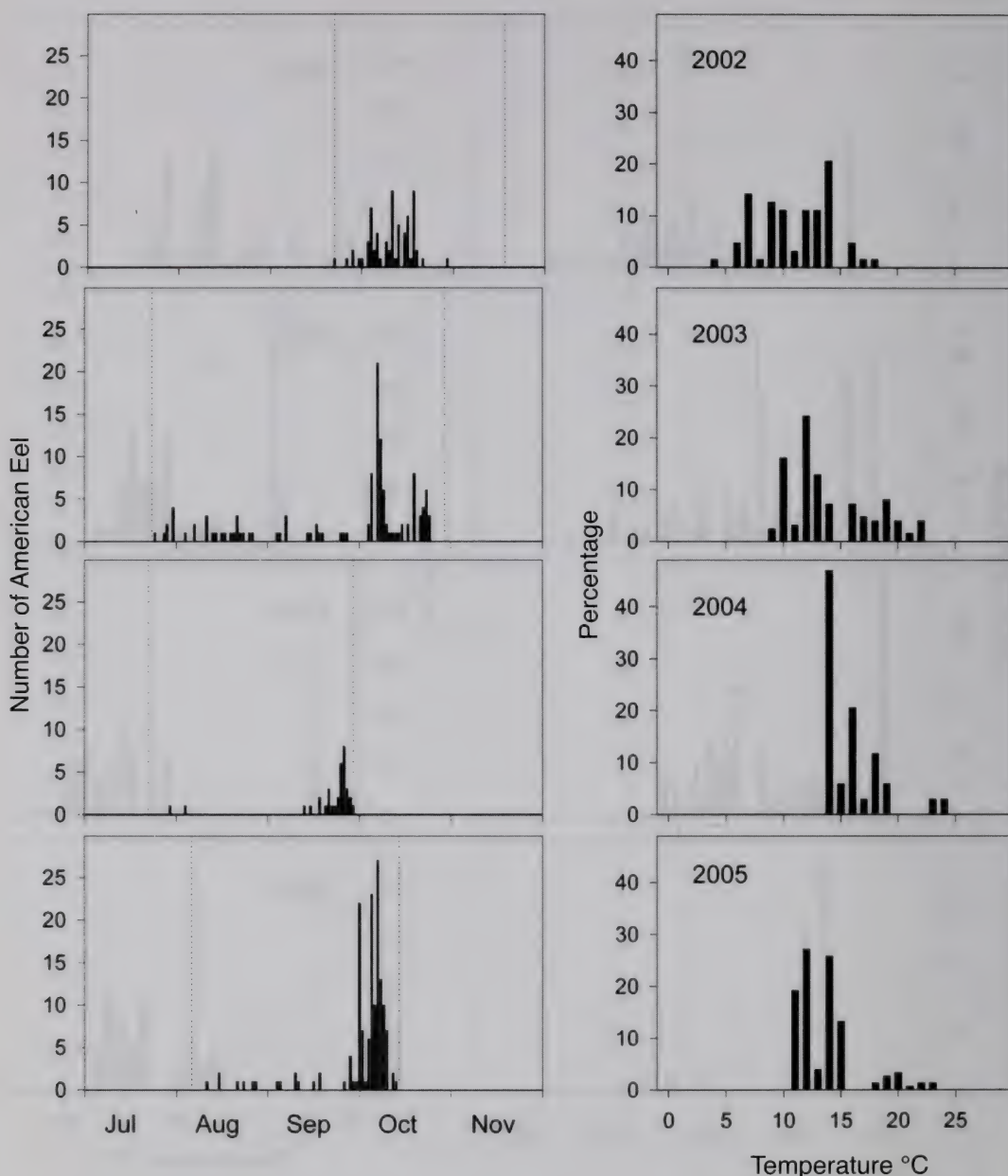


FIGURE 7. Daily catches of American Eel (*Anguilla rostrata*) from the combined catches of both traps (MT + RT) in the Tabusintac River 2002-2005. Dotted vertical lines represent the beginning and end of sampling. Right side panels show catches (as percent) in relation to temperature.

remaining dominant taxa were all diadromous (refer to McDowall 1987) and consisted of one catadromous eel, *A. rostrata* and five anadromous taxa including *Alosa* spp. (*A. pseudoharengus*, *A. aestivalis*), *M. saxatilis*, *S. salar*, *S. fontinalis* and *M. tomcod*.

The Tabusintac River Estuary fish assemblage contains several characteristics that identify it as a typical

north temperate estuarine assemblage. The assemblage contains few species. The dominant species are primarily derived from marine forms, most of which are anadromous and seasonally abundant in rivers usually for the purposes of spawning and it seems, to a lesser extent for feeding. In addition, many of the species taken (e.g., Salmonidae, Clupeidae, American Eel,



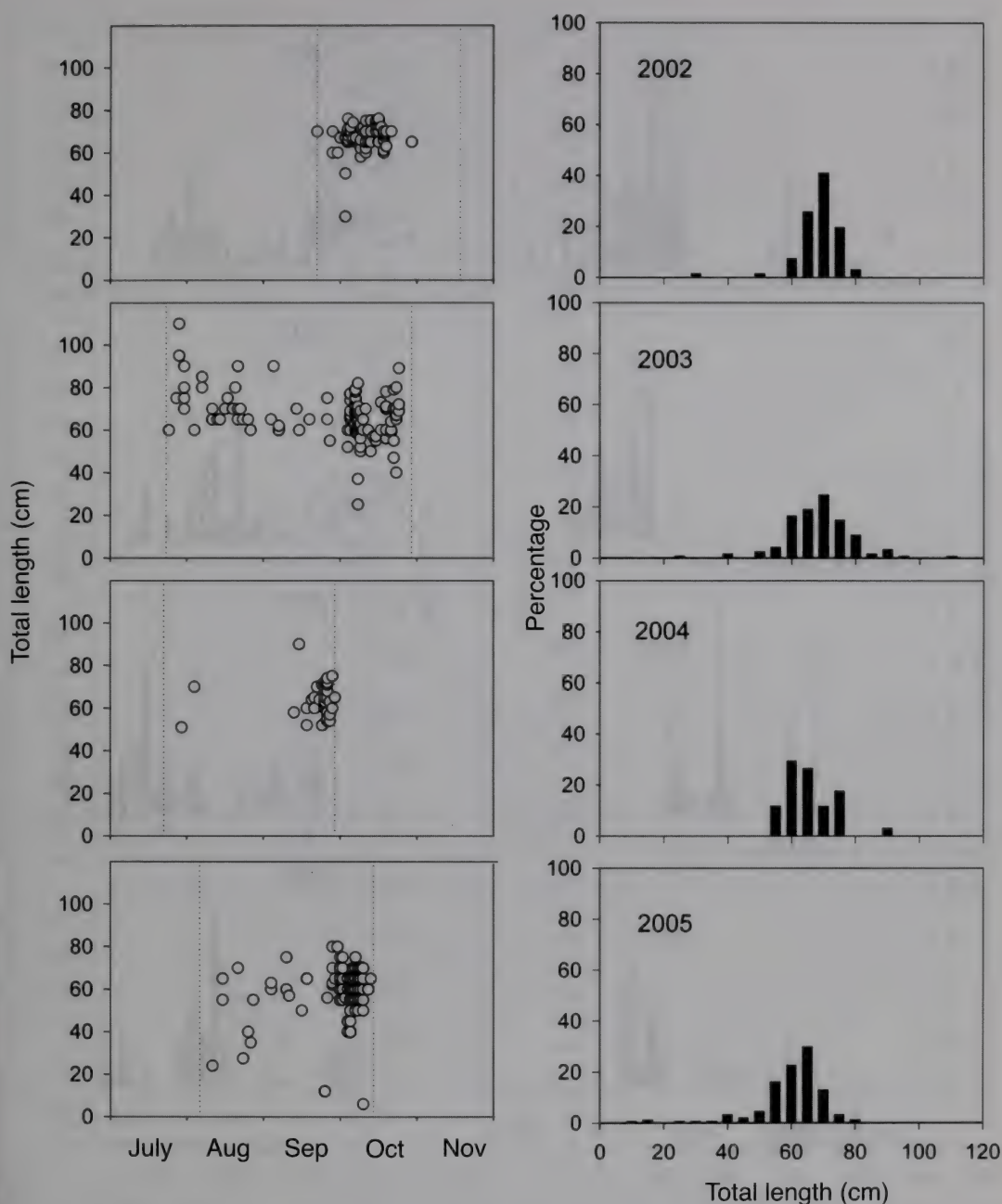


FIGURE 8. Daily lengths of individual American Eel (*Anguilla rostrata*) and length frequencies (as percent) calculated from both traps combined (MT + RT) in the Tabusintac River 2002-2005. Dotted vertical lines represent the beginning and end of sampling.

White Sucker, American Smelt, Sea Lamprey) contain primitive character sets as mentioned previously by McDowall (1987). This contrasts with tropical estuaries where anadromous species are rare and where

species that spend their entire life in estuaries are more prominent (Haedrich 1983; McDowall 1987; Potter et al. 1990). In addition, some of the most important fish families listed by Haedrich (1983) that are char-

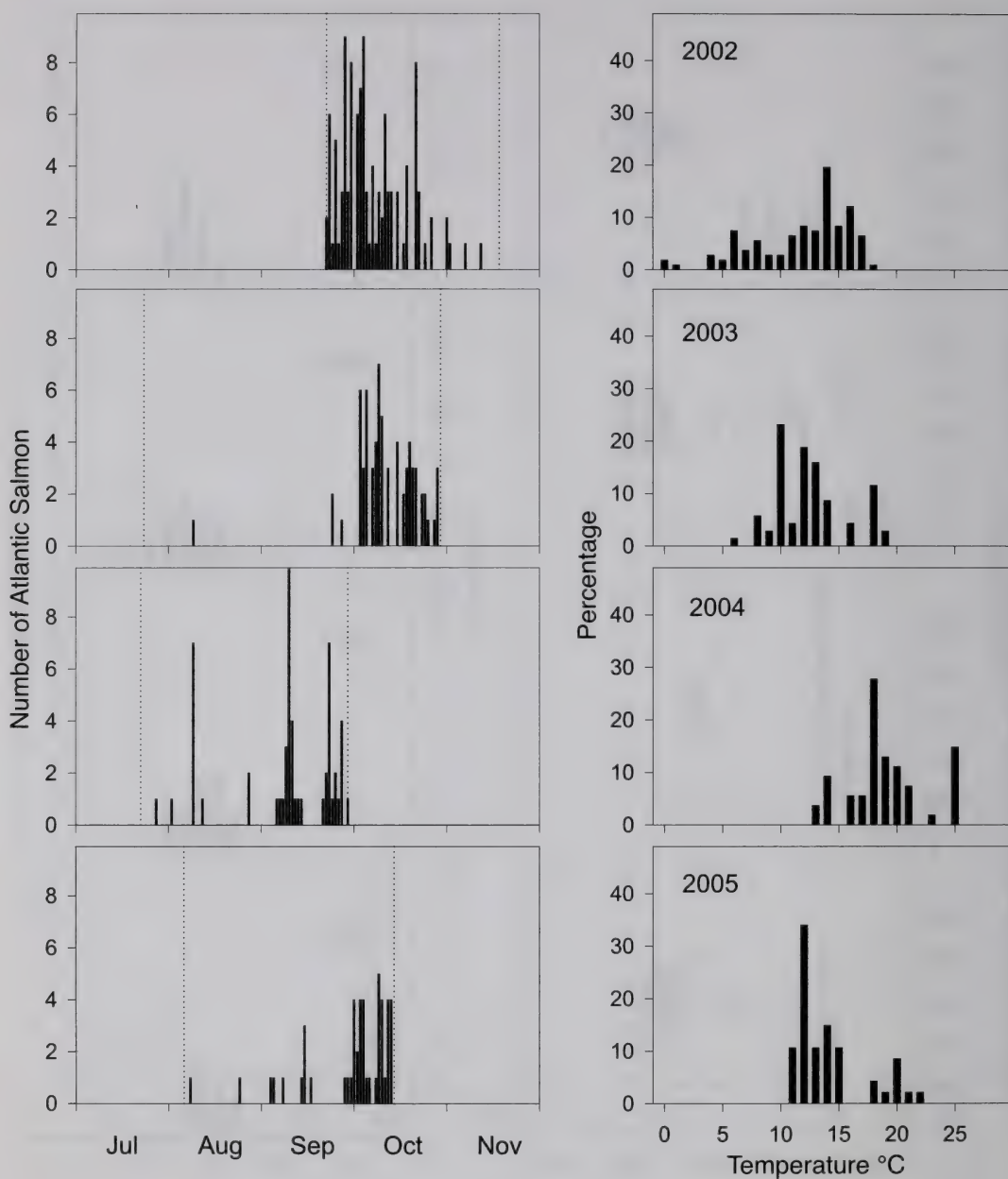


FIGURE 9. Daily catches of Atlantic Salmon (*Salmo salar*) from the combined catches of both traps (MT + RT) in the Tabusintac River 2002-2005. Dotted vertical lines represent the beginning and end of sampling. Right side panels show catches (as percent) in relation to temperature.

acteristic of temperate and boreal estuaries were taken at our two sampling sites. These include Anguillidae (freshwater eels), Clupeidae (herrings), Gadidae (cods), Gasterosteidae (sticklebacks), Moronidae (temperate basses), Pleuronectidae (right eyed flounders), Salmonidae (trout, salmon) and Osmeridae (smelt,

capelin). With the exceptions of the Gadidae and Pleuronectidae, all of these families have strong affinities to north temperate estuaries with a high proportion of species feeding, spawning or using the estuary as a migration corridor to fresh water spawning sites. Gadidae and Pleuronectidae differ from the other families



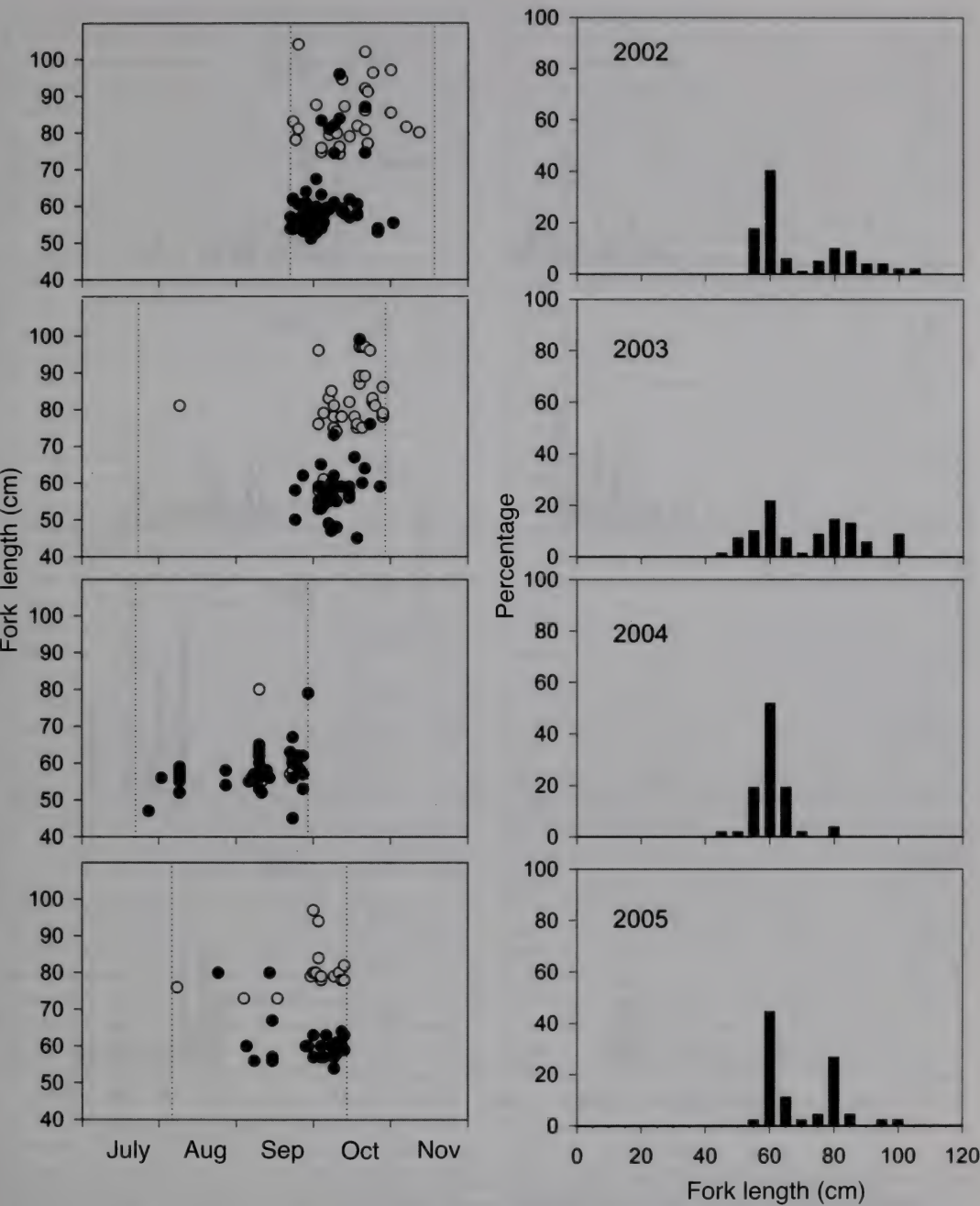


FIGURE 10. Daily lengths of individual male (●) and female (○) Salmon (*Salmo salar*) and length frequencies (as percent) calculated from both traps combined (MT + RT) in the Tabusintac River 2002-2005. Dotted vertical lines represent the beginning and end of sampling.

in that most species in these families spawn and complete their life cycle in marine waters (Scott and Scott 1988; Collette and Klein-MacPhee 2002). Exceptions include *Microgadus tomcod* (Gadidae) and *Pseudopleuronectes americanus* and *Pleuronectes putnami* (Pleuronectidae) all of which were taken in low salinity water in our study. Catches of both flatfish species were generally low (<5) in our study with the

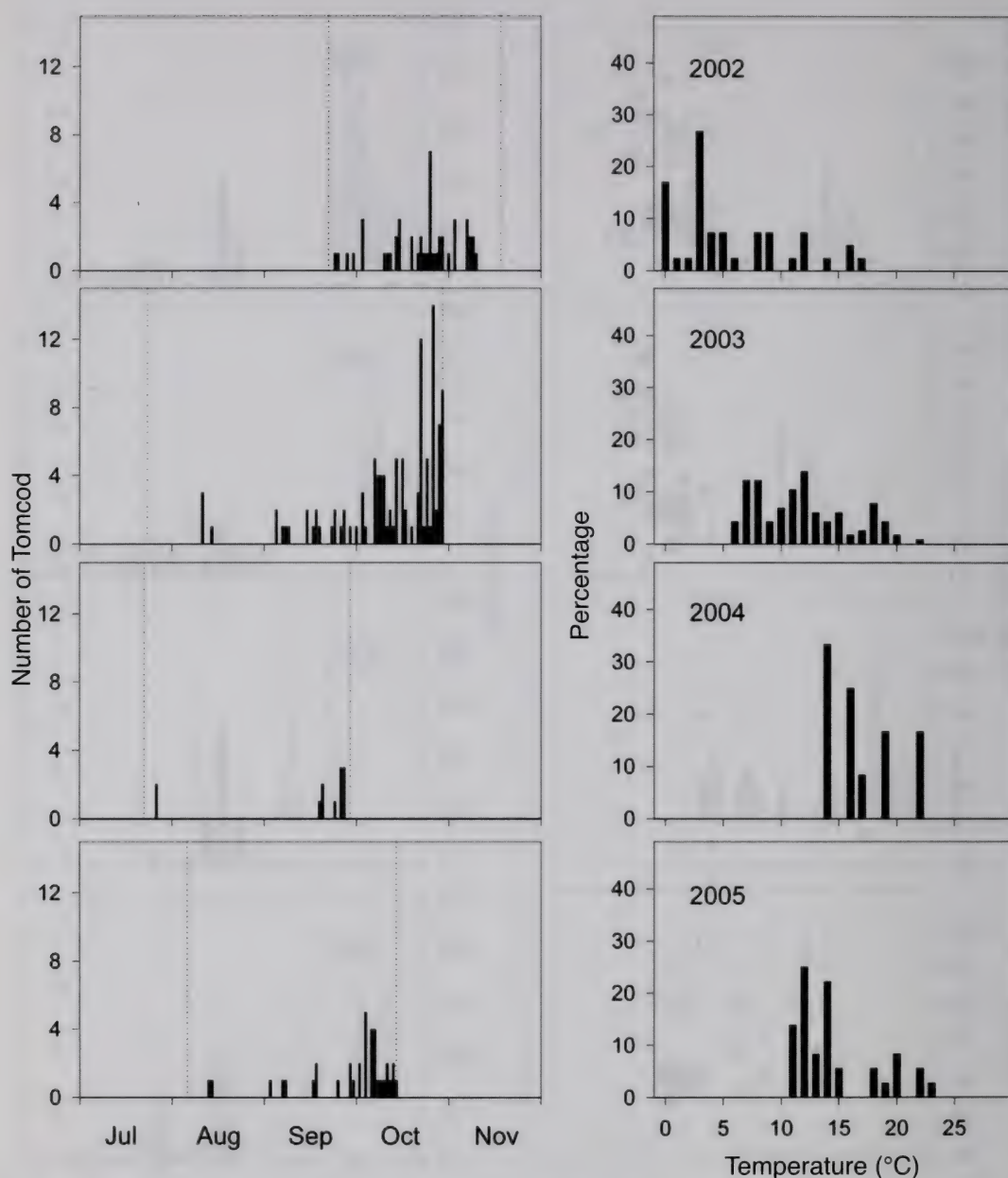


FIGURE 11. Daily catches of Tomcod (*Microgadus tomcod*) from the combined catches of both traps (MT + RT) in the Tabusintac River 2002-2005. Dotted vertical lines represent the beginning and end of sampling. Right side panels show catches (as percent) in relation to temperature.

exception of five days when catches exceeded 15 fish per day. Both species have been collected in the nearby Miramichi River and Estuary (Hanson and Courtenay 1996; 1997) and we observed approximately equal proportions of both species in the Tabusintac River in 2007. We conclude that both species very likely occurred at our sites in 2002-2005.

Families that were not caught (Gasterosteidae), or that were poorly represented (Osmeridae) were likely present in greater numbers in the Tabusintac River Estuary but were not retained in our traps due to the relatively large mesh size (50 mm). Acipenseridae (sturgeons) is another important estuarine family off eastern Canada (Scott and Scott 1988). Neither of the



two local sturgeon species (*Acipenser oxyrinchus* and *A. brevirostrum*; Atlantic and Shortnose sturgeons respectively) were taken in the Tabusintac River Estuary during our study, nor are they reported by Hanson and Courtenay (1995). McKenzie (1959), however, notes that up to half a dozen were taken each year in the main stem of Miramichi Bay from May to December. Chaput (1995) also notes that *A. oxyrinchus* is occasionally taken in the Miramichi River.

The overall composition of the Tabusintac River fish assemblage is influenced by pre- and post-spawning movements of several dominant anadromous species. April to June is the most intense period in terms of diversity and abundance of fishes migrating upstream and downstream in the nearby Miramichi River with summer having a less diverse fish fauna (Chaput 1995). Diversity and abundance increase again in fall (Chaput 1995). Given the close proximity of the two river systems, Chaput's observations appear to apply to the Tabusintac River. Early seasonal catches in our study were dominated by two post spawning *Alosa* species that had highest catches from mid July to early August. This is approximately two months after *A. pseudoharengus* is reported to spawn (May to June) in the Miramichi River (McKenzie 1959). High catches of these two species in the Tabusintac River decline shortly after mid August (<10 fish per day). Hence, the large catches we report (sometimes >200 fish per day) from mid July to early August likely consist of post spawning fish moving downstream. Spawning times for the Blueback Herring (*A. aestivalis*) are poorly known (Scott and Scott 1988) due to difficulties distinguishing these two species, but are reported to be 10-14 days after *A. pseudoharengus* spawns (Chaput and Atkinson 2001). Consequently "... Bluebacks spawn later than Alewives, the beginning of their spawning run commencing when the Alewife run is declining. Thus the spawning runs of the two species are reported to overlap when both species use the same spawning stream" (Scott and Scott 1988:103).

The *Alosa* upstream spawning migration is related to water temperature and occurs earlier in the southern part of the range (Scott and Crossman 1998). The minimum spawning temperature for these two species is 10-14°C with spawning ceasing at approximately 27°C (Jones et al. 1978). Water temperature in the Tabusintac River peaked in late July (20-25°C) at about the time when catches of these two species were highest in our study. This supports the observation that most of the *Alosa* caught in the Tabusintac River during our study were post spawned fish on their way downstream. Further support for the *Alosa* caught in this study being post spawned fish comes from observations during the last half of June when the two box traps were being built at the MT and RT sites. During this time (about 2 weeks) high densities of *Alosa* were occasionally observed in very shallow water (< 60 cm) along the rocky shore. Fish were observed to be cir-

cling close together, sometimes with half of their body visible above the water. It was not uncommon to hear fish splashing in shallow water at this time. The water became very murky due to milt being released during spawning and due to the loss of scales and mucus from fish in close contact. The mud substratum was also disturbed and suspended in the shallow water. This observation, made several times by AMH is very similar to observations of McKenzie (1959: 813) for *Alosa* spawning in the Miramichi River: "As they [*Alosa*] move upstream, many of them close to shore, groups of fish are often seen swimming rapidly anti-clockwise in a circle 1-2 m wide. In a matter of seconds the so-called nuptial dance or swim ends in a big splash".

*Catostomus commersoni* is next in the phenological succession of dominant species taken in the Tabusintac River after *Alosa* spp. *Catostomus commersoni* is a member of the sucker family Catostomidae, a family of freshwater fishes found only in the North Hemisphere. It occurs throughout much of New Brunswick (McKenzie 1959; Scott 1967; Scott and Crossman 1998). The biology of White Sucker in Canada is well known as a result of its abundance and widespread distribution and is summarized by Scott and Crossman (1998). Catches of *C. commersoni*, with the exception of 2003 were generally punctuated and usually of short duration. *Catostomus commersoni* was most abundant from late August to early October (20-10°C) and was the only dominant freshwater species taken. Spawning occurs from early May to early June, sometimes in lakes, but usually in gravel substrate of streams, when adults migrate from lakes at temperatures of approximately 10°C (Scott and Crossman 1998). We conclude that White Sucker taken in our traps were post spawned fish, given that adults begin moving off the spawning grounds to lakes 10-14 days after spawning begins (Scott and Crossman 1998), and that we did not observe eggs or milt being released when the many fish collected were handled and removed from the traps each day. Consequently, it is possible that White Sucker were moving both upstream and downstream when caught, given that tributaries to lakes and ponds occur in both directions from our trap sites. Scott and Crossman (1998) concluded that movements (other than spawning migrations and the general tendency to move offshore with increasing age) are random, probably in response to temperature.

The poorly defined catches of *C. commersoni* from late August to early October were followed by low catches of *Microgadus tomcod*, *Anguilla rostrata* and *Salmo salar* in September, October and November. Most of the catch data for these species also appears to be related to spawning migrations. Catches of *Microgadus tomcod* were highest when water temperature was declining in September and October (17-3°C), a time of year when feeding is reported to be high (Collette and Klein-MacPhee 2002). Mean catches prior to September were very low (<3-4 fish per trap day).

During autumn, large numbers of adults return to the Miramichi Estuary (just south of the Tabusintac River) and are caught downstream of Newcastle by bottom trawls and smelt traps (McKenzie 1959; Hanson and Courtenay 1995). Our small catches of Tomcod in autumn just precede the main upstream migration that takes place in November and early December in the Tabusintac and Miramichi Rivers (McKenzie 1959). Spawning occurs in December and January near the upper limit of saltwater intrusion (McKenzie 1959; Percy and Richards 1962; Booth 1967; Fahay 2007) usually in association with ice cover (Vladykov 1955; Booth 1967; Collette and Klein-MacPhee 2002). After spawning, adult Tomcod migrate downstream from February to May (Vladykov 1955; McKenzie 1959). Spawning occurs when Tomcod are 17–18 cm (Vladykov 1955; Collette and Klein-MacPhee 2002). Length of *M. tomcod* in our study was not measured, but most were 14–22 cm. Weakly adhesive demersal eggs (Fahay 2007) stick together in masses or adhere to algae or stones on sand or gravel bottoms (Booth 1967; Collette and Klein-MacPhee 2002). Eggs can accumulate in the interstitial spaces of ice and are transported downriver during ice breakup in spring and hatch (R. Cunjak personal communication). Incubation time at 0°C is 44–70 days (Leim and Scott 1966) and larvae were taken in May and June in low salinity waters of the Miramichi Estuary (Locke and Courtenay 1995).

*Anguilla rostrata* is another species with high catches in October when water temperature was declining (17 to <10°C). Once abundant in streams and rivers of eastern Canada (McKenzie 1959; Scott and Crossman 1998), this species now shows substantial declines in commercial landings (Cairns 2005). Commercial fyke net catches in Atlantic Canada are highest in autumn (Cairns 2005) when mature American Eels migrate downstream to marine spawning sites (Collette and Klein-MacPhee 2002).

Eels were not sexed in our study but most (83%) were greater than 60 cm TL and appear to be predominantly female. Sex determination in *Anguilla rostrata* appears to be strongly influenced by density, with high densities promoting the production of males (COSEWIC 2006a). Eels in the upper St. Lawrence River and Lake Ontario are virtually all females and females dominate in many other locations in Canada (COSEWIC 2006a). Females mature at and attain larger sizes than males (Scott and Scott 1988; Collette and Klein-MacPhee 2002). The smallest mature males measure 28 cm. Females mature at approximately 45 cm (Collette and Klein-MacPhee 2002). Eels found in rivers flowing into the Gulf of Maine that are greater than 60 cm are almost certain to be female (Collette and Klein-MacPhee 2002). In Canadian waters, females can exceed 100 cm whereas males seldom exceed 61 cm (Scott and Scott 1988). Bouillon and Haedrich (1985) did not report any males over 40 cm from Newfound-

land rivers. If these observations are applicable to the Tabusintac River then the majority of Eels caught in our study, most of which were greater than 60 cm, were predominantly female. Hence, the high proportion of large Eels taken in the Tabusintac River in autumn (the time reported for downstream spawning migrations; Collette and Klein-MacPhee 2002) suggests that these were maturing Eels migrating downstream on their way to marine spawning sites.

Eels were common from spring to autumn as evidenced by catches in the commercial fishery in the Miramichi River and estuary (Hanson and Courtenay 1995). This estuarine occurrence is also noted by McKenzie (1959) who reported up to 6818 kg taken in Miramichi Bay and adjacent rivers by commercial fishers in some years and that historically, great quantities were taken in holes through the ice with spears, a fishery that continues in parts of Atlantic Canada (Cairns 1997). Recent work based on otolith strontium-to-calcium ratios from two estuaries in Prince Edward Island indicates *A. rostrata* can complete its entire life cycle in the sea by making extensive use of estuaries (Lamson et al. 2006). Hence, the catadromy paradigm for the American Eel from Atlantic Canada is overturned (Lamson et al. 2006). The high representation of exclusive salt-water residency in Eels (84.6%) suggests that non-catadromy may be an important and common pattern for the American Eel (Lamson et al. 2006) although some undoubtedly show both patterns.

Highest catches of *S. salar* occurred in September and October at approximately 15°C when temperatures were decreasing. All Atlantic Salmon taken in our traps were adults (most >60 cm) that were migrating upstream in October and November (Scott and Scott 1988). Atlantic Salmon were also caught in July (2004,  $n=1$ ) and August (2003,  $n=1$ ; 2004,  $n=11$ ; 2005,  $n=2$ ). This is weeks before the run starts in September. Atlantic Salmon returning to the Tabusintac River are a mixture of fish that have spent one or two winters at sea, with most small Atlantic Salmon being males and most large Salmon being females, a pattern that is consistent for salmon returning to natal rivers in the Gulf of St. Lawrence and Québec (O'Connell et al. 2006). The largest Atlantic Salmon, those few fish that were greater than 95 cm, appear to be three-sea-winter fish (O'Connell et al. 2006) that are predominantly female.

Over the four-year duration of our study, numbers of Salmon decreased from 2002 ( $n=113$ ) to 2005 ( $n=38$ ) however sampling effort was not standardized due to the different start and finish dates of sampling each year. Future sampling at these sites must standardize the size and type of traps used as well as the start and finish dates of sampling to make among year comparisons meaningful. For example, sampling ceased in late September 2004. This is before most Salmon arrive in the fall migration (usually early October, as observed in 2002, 2003, 2005) and this result-



ed in only 46 common days of sampling from 2003 to 2005 (12 August to 26 September). Consequently it is difficult to draw conclusions regarding increasing or decreasing abundance of this much prized and once heavily exploited species. The ideal window of sampling to appropriately monitor the fall migration of Salmon returning to the Tabusintac River Estuary would appear to be 1 August to 31 October (possibly later). Future monitoring of the Tabusintac River population in August, September and October would provide data to assess the conservation status of this species, an important objective given that the inner Bay of Fundy population as has been listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Endangered and that many other wild populations of *S. salar* are now extinct on a global scale (COSEWIC 2006b). Data that are available for catches of *S. salar* on the Tabusintac River for traps at the two sampling sites during the common days of sampling over the last decade are quite variable, but do show a decreasing trend when combined with data in Table 2 due to the high catches in 1999 (1998: 43; 1999: 176; 2002: 30+; 2003: 4; 2004: 51; 2005: 12; 2006: 9; 2007: 10; 2008: 16). No sampling was done in 2000 and 2001 and there were only eight days of sampling within the 12 August to 26 September window of common days in 2002 when 30 Atlantic Salmon were caught (Figure 9).

Striped Bass were collected each month but catches tended to be highest from September to early November when water temperature was decreasing from approximately 17 to 3°C. Striped Bass apparently spawn only in two locations in Atlantic Canada, the Stewiacke River, a tributary of the Shubenacadie River in the lower Bay of Fundy and in the Miramichi River, just south of the Tabusintac River (COSEWIC 2004). Spawning occurs in May or June in fresh or slightly brackish water at temperatures greater than 10°C (Raney et al. 1952; Scott and Scott 1988). After spawning, adults (i.e., males >30 cm [age 3]; females >40 cm [ages 4-5]; COSEWIC 2004) move down river and enter coastal estuaries where they may remain, or migrate further along the coast to feed (Douglas et al. 2003). When water temperature decreases in autumn, Striped Bass gradually migrate upriver where they overwinter (Magnin and Beaulieu 1967; Jessop 1991). A particularly unique feature of Canadian Striped Bass populations is that they overwinter in rivers or lakes under ice in order to escape cold ocean temperatures (COSEWIC 2004). These repeated upriver migrations in autumn, make deciphering the life history and movements of Striped Bass challenging. This is due, in part to Striped Bass being an amphidromous species (Chaput 1995), a diadromous species that migrates between marine and freshwater but not for the sole purpose of spawning.

Striped Bass were caught throughout summer in the Tabusintac River. Three size modes (approximately

10-15, 25-35, 45-65 cm) were observed in some years. Some modes show evidence of growth as indicated by very slight positive slopes of increasing length (Figure 4) which we speculate is suggestive of Striped Bass remaining in the Tabusintac River and growing during that time. Other size modes show no evidence of growth, suggesting a more rapid turnover in the vicinity of our traps. Catches of Striped Bass in our traps on the Tabusintac River were very pulsed, especially in 2003 (Figure 3). Three peaks in catches of Striped Bass were reported by Chaput and Randall (1990) on the Miramichi River, the second (summer) and third (fall) of which were believed to correspond to movements for feeding. We see no evidence of a pulse of big fish returning in autumn to migrate upstream with the possible exception of some very large fish (>70 cm) in 2002, the year that sampling extended latest in the autumn (8 November; Table 1).

Of particular interest is the capture of Striped Bass in 2003 ( $n=53$ ) and 2005 ( $n=6$ ) that were less than 10 cm. These are young-of-the-year fish, just three to four months old (Douglas et al. 2003) that have apparently migrated from the closest known spawning grounds in the Miramichi River. If these YOY originate from an early June spawning in the Miramichi River (COSEWIC 2004) then this is a conservatively estimated minimum distance of 60 km travelled from early June to being collected in our traps 14 km up the Tabusintac River in early August and September. Some of these YOY are less than 6 cm and much of this distance is against prevailing currents indicating that these fish are capable of moving considerable distances at small sizes.

## Acknowledgments

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## Notes

### Long Daily Movements of Wolves, *Canis lupus*, During Pup Rearing

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Mech, L. David, and H. Dean Cluff. 2009. Long daily movements of Wolves (*Canis lupus*) during pup rearing. *Canadian Field-Naturalist* 123(1): 68-69.

Wolves, *Canis lupus*, on Ellesmere Island traveled a daily round-trip distance of 40.2 km from their den to a landfill during July 2008, plus an undetermined distance hunting after leaving the landfill. Although long travels by Wolves are well known, this appears to be the first documentation of long daily movements by Wolves rearing pups.

Key Words: Wolf, *Canis lupus*, movements, travel, den, foraging, Ellesmere Island, Nunavut.

Long travels of Wolves (*Canis lupus*) are well documented (Mech and Boitani 2003), including extreme individual moves from dens (Mech 1988; Frame et al. 2004). However, no information is available about long, routine daily travels of Wolves to and from dens or rendezvous sites. Herein we document such movements of Wolves on Ellesmere Island, Nunavut, Canada.

#### Study Area

The study area includes part of the Fosheim Peninsula near Eureka on Ellesmere Island (80°N latitude, 86°W longitude), Nunavut, Canada. During summer daylight is constant. The area includes a fiord with ice floes, shoreline, hills, lowlands, creek bottoms, mud flats, a weather station, military base, an airstrip and a garbage landfill. Contrary to much of the surrounding region, this area is generally snow- and ice-free in summer, and contains rock, gravel, bare soil and scattered tundra and northern wetland vegetation. Wolves, Muskoxen (*Ovibos moschatus*) and Arctic Hares (*Lepus arcticus*), have long been common in the area (Tener 1954), and Wolves have denned there over decades or possibly centuries (Parmelee 1964; Grace 1976; Mech 1988; Mech and Packard 1990). Aside from intermittent scavenging from the landfill, the Wolves here feed on Muskoxen and Arctic Hares (Tener 1954), although Seals (*Phoca* spp.) and Lemmings (*Dicrostonyx groenlandicus*) are also taken occasionally.

#### Methods

We studied Wolves using the garbage landfill in the study area from 3 through 17 July 2008, observing the Wolves there and when possible backtracking them as far as possible and/or following them directly via

all-terrain vehicles (ATVs) and binoculars and deducing the direction of their den. We then searched the area in that direction on foot, via ATVs, and by helicopter. When searching from the ground, we scanned large areas by binoculars and howled periodically in an attempt to trigger replies or encourage Wolves to expose themselves. In this way, we ruled out large expanses and thus narrowed the probable location of the den. Tracking in several key areas was facilitated by loose sand, fine gravel, and mud flats of creeks and rivers, and we cleared such areas of tracks regularly so we could determine ages of new tracks. When we located the possible den or rendezvous site (RS), we observed the area from 4.1 km away via 15× and 12× image-stabilized binoculars and a 30× spotting scope. We identified Wolves as a breeding male (Wolf 1) by his raised-leg urinations (RLUs) (Peters and Mech 1975), a breeding female by her apparent nipples (Wolf 2), and 2 non-breeders by their lack of either RLUs or nipples. The two non-breeders were distinguishable from each other by one having a grayish mane (Wolf 3) and the other, a light orange cast to its shoulders (Wolf 4). We measured distances with a Garmin GPSmap 76S global positioning system mounted on an ATV. (Mention of brand name does not imply endorsement by the U.S. government.)

#### Results

We observed Wolves 1 and 2 twice, Wolf 3 three times, and Wolf 4 once, primarily around the landfill during the evening, plus we believe that Wolves 2, 3, and 4 were also included in a pack of eight also seen there later (Table 1). Wolf 1, a raised-leg urinating male was not with the eight. Due to favorable tracking conditions, we were able to backtrack Wolf 2 some



11 km during one trip to the landfill and toward the possible den/RS, and we followed her visually for 3 km on her trip 8.5 hr later back toward the possible den/RS. We observed Wolves 1-3 traveling together on 6 July for 4.5 km from 2115 to 2225 hr, indicating that they were of the same pack, and we backtracked them to the direction of the possible den/RS. A profusion of old and fresh Wolf tracks led to and from the landfill 16 km to a 2-km wide mud flats and disappeared across the flats to the possible den/RS. We observed an unidentified Wolf on 12 July walking down a ridge some 4.1 km away across the mudflats, and on 13 July a possible Wolf on the top of the same ridge traveling away at 1815 hr for about 1 km. The animal was white, the same color as Arctic Hares (*Lepus arcticus*) on this island, but did not appear to be moving in the manner of a Hare. Although we could not be certain this animal was a Wolf, we concluded that it most likely was and that the area it came from was probably the den/RS. We had also spent hours scanning the rest of the area across the flats without seeing Wolves or identifying any other possible den/RS.

## Discussion

We could not cross the mudflats/river to follow Wolf tracks across, but could deduce that the den/RS could not have been on those flats so had to be on the highland on the other side. Wolves 1-3 had to have been traveling regularly a minimum of 17.6 km from the opposite side of the mudflats to the landfill, or 20.1 km from the probable den/RS to the landfill, a minimum 40.2-km roundtrip. In addition, they must have traveled many more km during their travels after leaving the landfill, for except for Wolf 2 on 5 July, the Wolves spent only a short time at the landfill, and did not appear to have obtained a large amount of food. Although these daily travels fall far shy of the 48-km trip from a den to a kill measured by Mech (1988) in this same area and the 341 km, 14-day trip away from and back to a den documented by Frame et al. (2004) in the Northwest Territories, they do indicate that even on a daily basis, Wolves can and do travel long distances from their pups to obtain food.

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TABLE 1. Known Wolf visits to a landfill on Ellesmere Island in July 2008.<sup>a</sup>

Date	Wolf No.	Time of visit
3 July	3	2215-2315
4 July	1	2030-2230
5-6 July	2	2050-0410
6 July	3	0415
8 July	1,2,3	2115-2225
12 July	4	2050-2320
16-17 July	1-8 <sup>b</sup>	2340-0300

<sup>a</sup> Additional Wolf visits during other days of the study were observed by other people and were documented by us through fresh tracks.

<sup>b</sup> We believed these eight Wolves which came from the direction of the den and returned that way, included Wolves 2, 3 and 4, but cannot be certain. However, they did not include Wolf 1, discernible by his raised-leg urination; only a female (presumably Wolf 2) was marking and that was with a flexed-leg urination (Mech 2006).

manuscript and offered helpful suggestions for its improvement: D. MacNulty, and S. Barber-Meyer. This is PCSP/EPCP paper 03808.

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# Unpaired Drake Avoidance Behaviour and Mate Recognition by Female Mallard, *Anas platyrhynchos*, During the Spring Breeding Season

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MacKinnon, Colin M., and Nancy M. (Lutz) MacKinnon. 2008 Unpaired drake avoidance behaviour and mate recognition by female Mallard (*Anas platyrhynchos*) during the spring breeding season. Canadian Field-Naturalist 123(1): 70-71.

An observation of a female Mallard (*Anas platyrhynchos*) avoiding unpaired drakes, in breeding season, until reuniting with her mate after audio recognition of the *rähb* call. This observation supports the supposition that this vocalization by the male Mallard is a response to separation from the female and functions as a contact call in mate recognition.

Key Words: Mallard, *Anas platyrhynchos*, courtship, *rähb* call, mate recognition, Sackville Waterfowl Park, New Brunswick.

Among waterfowl, the Mallard (*Anas platyrhynchos*) is one of the more studied species. Drilling et al. (2002) covered in detail all aspects of Mallard life history, citing an extensive list of reference work for this species. Mallard behaviour, as it relates to mating, courtship, mate-guarding and the maintenance of the pair bond has been the focus of much research (Humburg et al. 1978; McKinney et al. 1983; Titman 1983; Goodburn 1984; Losito and Baldassarre 1996). Mallards are monogamous; however, paired males will force-mate with other females (as by pursuit flights) as well as guard their mate, especially during the period when the female is fertile. The paired female will also evade pursuit by males, other than their mate, by flying, running, hiding and/or diving (Drilling et al. 2002).

Mallards, especially the females, have a wide range of vocalizations. The less vocal male has a *rähb* call described as "quieter" than the female's *quack* (Klint 1980). Klint (1980) suggests that male Mallards respond with this *rähb* call when separated from their female mate; thus, this vocalization may function as a contact call. As one might expect, there is a range of male and female interactions associated with the pair bond during the breeding season as well as various responses to other influences, such as other males that might force copulation. The following observations bring together a series of behavioural responses between what were presumably a pair of Mallard ducks in avoidance of potential conflicts with other male Mallards in the near vicinity.

At 19:10 on 15 April 2008 we observed a wild female Mallard in a head-tucked, motionless resting position on a raised portion of upland adjacent to a boardwalk trail. The trail is situated within a 19 ha freshwater wetland known as the Sackville Waterfowl Park (Hanson et al. 1994). A portion of the wooden-decked trail is supported by a narrow vegetated island (~4 m wide)

dominated by what is believed to be a hybrid birch "Blue Birch" (*Betula pendula* × *B. populifolia*) with a diameter at breast height (dbh) ranging from 5 to 10 cm. The understory is open with little ground cover. The female was motionless (as if sitting on a nest) and we approached, while staying on the boardwalk, to within 2 m. While we viewed the female, two drake Mallards were seen in shallow open water, ~20 m away through the trees, feeding and making low vocalizations (feeding chuckle call). At about 19:11 a third drake landed in the vicinity of the aforementioned two and also began to feed. Just minutes prior to the start of this observation, we noted a pursuit flight of 2 male:1 female Mallard overhead: evidence that breeding was well underway and that females were being actively pursued.

We watched the silent motionless female for about 2 minutes when a fourth drake Mallard landed in the open water about 20 m behind the female and about 20 m away from the aforementioned feeding drakes. On landing, the drake immediately started making a low 'quacking' noise (the *rähb* call as described by Klint 1980); by the first or second call the female quickly raised her head and, turning 180°, immediately entered the water. As soon as the female began moving, the vocalizing drake proceeded to meet her and they swam parallel to each other, under cover of vegetation next to the island, away from the three drakes that were still feeding in the open water. The female and drake were still in close proximity (< 0.5 m) when the observation ceased at 19:15. At the time of observation, wind was essentially nil, with a clear sky and mild temperatures at 14°C.

These observations support the observation made by Klint (1980) suggesting that the *rähb* call is a male Mallard response to separation from its mate and thus functions as a contact call. Furthermore, these obser-



vations place the *rähh* call in the context of a paired female which clearly avoided detection by other male Mallards while silently making audio mate recognition.

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# Book Reviews

**Book Review Editor's Note:** We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Renminbi are CNY, Australian dollars are AUD and so on.

## ZOOLOGY

### **Birds of East Asia – China, Taiwan, Korea, Japan and Russia**

By M. Brazil. 2009. Helm Field Guides, A & C Black Publishers Limited, 38 Soho Square, London U.K. W1D 3HB. 528 pages. 29.99 GBP, Paper.

This book is a milestone field guide publication as it fills a major gap and will be highly appreciated by naturalists, birders, and researchers alike in the Pacific Rim (eastern Russia, Japan, China, Taiwan, the Koreas and Pacific Islands) and beyond. The North American audience will also highly appreciate this book (e.g., for Alaska, Hawaii, Guam and British Columbia) because it presents for the first time a thorough description, reference, and guide for the Far East Asian bird species which occur every year "on the other side". For people working in the Far East, this is a long-awaited high-quality publication of 515 pages with 11 sections to be used for your daily work in the field (the book is rather compact, resists water and is quite easy to handle in one hand). Further, it will change how you do science there, and trigger reporting of species and new research for better ornithology overall.

The 236 color plates (coherently done by a list of 13 world-class illustrators: 130 non-passerine and 135 passerine plates with birds in typical postures, sometimes with their typical habitats) are a true delight and make for extremely useful support of the identification section; so do the maps (showing colors for Summer range, Resident, On migration, Winter range and Scarce). I appreciate the crisp but precise text on identification, status and distribution, habitat and habits, "bare parts" (bill shape, size and coloration, eye color, legs), voice, moult, as well as subspecies, morph, sex and age details. The geographic scope, taxonomy, nomenclature, bird habitats, migration, vagrancy, and "how to use this book" all get briefly introduced. All relevant components for a guide book are included; e.g., Avian Topography and Terminology, a Key to 92 Families, References (half a page, but extensive glossary and bibliography sections are available online at <http://sites.google.com/site/birdsofeastasia>), an Index (14 pages), and also a rather helpful one page Quick Index at the very end. The reader will further appreciate the Appendices on Status (by Country) and Potential Vagrants (perhaps a little short for such a huge region covering only 46 species). Plate 236 on "Extinct or Presumed Extinct Species" might be rather conser-

vative, as it covers only Spectacled Cormorant, Crested Shelduck, Eskimo Curlew, Bonin Woodpecker, Ryukyu Woodpecker, Miyako Kingfisher, Kittlitz's Thrush, and Bonin Grosbeak.

This book stands out in time and in ornithology beyond Asia! The sophisticated field guide covers 985 species which make up about  $\frac{1}{10}$ th of the global avian diversity. Its impact will generate better reporting of species and their ranges and occurrences in the wider Pacific region; e.g., for the high regional species diversity of "swans, geese and ducks", "buzzards, eagles, vultures and allies", "sandpipers, woodcock and snipe", "gulls and terns", "old world warblers", and "chats, robins and flycatchers". Rare Bird enthusiasts will have a feast here beyond warblers and buntings. This book shows that the Russian Far East and pelagic waters are still widely under-birded. The author (who has already achieved major publications with his rather impressive earlier work on Whooper Swans, the Birds of Japan and Birding in Japan) must be highly congratulated for this life-time publication, bringing biodiversity-related progress to Asia and the Pacific Rim as a whole.

I would only criticize four things in this book: (a) the maps could be a little bigger, (b) the book lacks any relevant sections on conservation and climate change (both show big impacts already, as can be seen by anybody working in the field), (c) the taxonomy and nomenclature do not follow ITIS but are a self-designed mix of references by the author based on Dickinson (2003) (which has value in itself though, because Brazil is an expert on these species overall), and (d) local Russian experts for this region should have been more involved (at least four experts were not involved at all, nor even mentioned). Species names could perhaps have been presented in Japanese, Mandarin, Korean and Russian? This book celebrates a globally well-established, white race (English) "Old Boys" birding network, a thing we ought to overcome, certainly for Asia. From my own work, I found small errors in some of the Russian species distribution maps. In times of digi birding and a wider Asian obsession with techno gimmicks, the publisher could have been



more supportive of such endeavors (as they help to document species, makes for a better identification, and immediate publication of sightings online).

Anyways, this book is the best field guide for its region and beyond, and leaves a global impact. It's to be placed in your bookshelf and used in the field a lot

for the challenges to come in times of globalization and massive Asian Growth!

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## Birds of East Asia – China, Taiwan, Korea, Japan and Russia

By M. Brazil. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 528 pages. 39.95 USD, Paper.

This book is a great contribution to the literature of a poorly covered region. It does, however raise some curious questions. The first is the area covered; it ranges from 116°E [just east of Hong Kong] to 165°E [the date line], from 20°N [Taiwan] to 78° N [about level with Grise Fiord]. About 80 per cent of the region selected is in Russia – Siberia and the Russian Far East. This leaves out most of China, but includes all of Taiwan, Korea, Japan [plus a smidgen of Mongolia]. It seems an odd choice to select portions of countries. It does mean that many North American birds are included; those that sneak their range from Alaska into the Russian Far East.

The format is typical of modern field guides; illustrations on the right and text on the left. Range maps are included with the text. In addition to the usual colour representations for summer, winter and permanent ranges, the author has added a pink zone for “scarce”, but scarce is not defined. True vagrants like North American warblers have no map only a range description and rare birds like Siberian Crane [critically endangered – population around 3200.] have regularly coloured maps. Instead scarce is used for birds like the Common Starling which strays to the Chinese coast in winter in small numbers. Despite my confusion this is a useful concept that should be copied by others.

Because of the book's chosen regional boundary, the reader can see 985 species with Great Blue Heron [accidental] and Grey Heron on the same page – a useful juxtaposition. Similarly Redhead, Canvasback and Common and Red-crested Pochard are all on one page. The book includes the Bering Sea alcids and around 30 buntings, some like Yellowhammer as vagrants and eight North American sparrows, again as vagrants [except Savannah Sparrow]. Thirty one gulls are depicted, of which 11 are vagrants, giving a wide coverage in a single book. Travellers will recognise birds from Europe, India, Polynesia, North America, Africa and even Antarctica.

The text, while brief, is clear and makes all the salient points. This includes discussions on the subspecies, especially where there is the likelihood of a split in the future [e.g., Eurasian Blackbird]. However, the author makes some odd statements. For example, under Great Blue Heron it says “some migrating as far as Canada to breed” – does he not know it is common

in much of our country? The voice of the Rusty Blackbird is given as a soft “chuck” not the classic “squeal like the creak of rusty hinges.” Only the calls, not the songs, of the North American warblers are given [which is probably valid for this region]. The Reed Parrotbill is shown as restricted to Eastern China. There is a question mark in Russia, but the bird does occur at Russia's Lake Khanka [north of Vladivostok]. The Cackling Goose (*Branta hutchinsii*), is incorrectly called a Lesser Canada Goose and Cackling Goose is identified as *B. h. minima* [correctly it is the Small Cackling Goose, one of the five subspecies of Cackling Goose]. *Branta canadensis* is called the Greater Canada Goose, but of the seven subspecies none are called Greater. Lesser Canada Goose properly denotes the subspecies *parvipes* of the Canada Goose. Recent DNA studies suggest that the Black-eared Kite (*M. m. lineatus*), here separated as *M. lineatus*, is not sufficiently distinctive to be called a separate species. The author includes the Tropical shearwater as a full species. *Puffinus bailloni*, but does not mention Audubon's Shearwater, *Puffinus ilherminieri*. This muddies an already confusing taxonomy. The current status is that the subspecies *Puffinus ilherminieri bailloni* breeds in the Indian Ocean. The subspecies *Puffinus ilherminieri dichrous* in central Polynesia and the Indian Ocean up, while *Puffinus ilherminieri bannermani* breeds on the Ogasawara Islands.

The Eurasian common names are used [diver instead of loon etc.] although some of are a little out of line. For example, Bearded Reedling is listed as Bearded Tit [having been re-displaced from the parrotbills, but not back into the tits.] *Aegypius monachus* is called the Monk Vulture [a valid but obscure name] rather than Cinerous or Eurasian Black Vulture.

The illustrations have been done by 13 artists so there are some style differences. The quality, however, is consistent and the reader will have no difficulty in the field. Birds like the Greenish Warbler are as good as they can be with such difficult species. Try putting Greenish Warbler in Google Images and comparing the photos with the illustrations. There are birds that are browner, with more or less prominent wing and eye stripes establishing how difficult it is to depict *Phylloscopus* warblers such as this one. The same can be said of the *Gallinago* snipes. The one place I did blink was the depiction of the 43 cm Little Bustard

and the 23 cm Slaty-legged Crake as being the same size. All the other plates are in proportion.

I was a little disappointed that the author did not put Vega and American Herring Gull on same page so the reader could make a more direct comparison. In general I found the colours accurate. The Wood Swallow is perhaps a little too dark and the female Barrow's Goldeneye's bill should be more yellow.

Despite some irritating points of confusion, I think it is an important and valuable addition to the world's field guides. It is a vast improvement over the 1984 *Birds of the USSR* by Flint, Boehme, Kostin and Kuz-

netsov [Princeton] as well as the dated Korean and Taiwanese English-language guides. This guide's main rival is *Birds of Europe, Russia, China and Japan: Passerines*, by Norman Arlott [Princeton], but this covers fewer genera and is less detailed with twice as many birds per page. Brazil's book adds significantly to the coverage by modern field guides and it will be a useful field book for residents [who read English] and visitors alike.

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## **Birds of the Horn of Africa – Ethiopia, Eritrea, Djibouti, Somalia, and Socotra**

By Nigel Redman, Terry Stevenson, and John Fanshawe. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 488 pages. 40.00 USD Paper.

This book covers the volatile countries of northeast Africa; Ethiopia, Eritrea, Djibouti and Somalia plus the islands of Socotra. Socotra is a part of the Republic of Yemen and is a group of four islands off the coast of the Horn 350 km south of the Arabian peninsula. It has well over 250 Socotran plant species of are found nowhere else. This includes the dragon's blood tree whose red sap was sold as dragon's blood. There are also several endemic birds, [Socotra Starling, Socotra Sunbird, Socotra Sparrow and Socotra Grosbeak]

The book follows the currently-used format for field guides. It covers over 1000 species and is fully illustrated. As soon as I opened the book I recognised some of the artwork. It is taken from Stevenson and Fanshawe's earlier book, *The Birds of East Africa: Kenya, Tanzania, Uganda, Rwanda, Burundi* (2006) [reviewed in *The Canadian Field-Naturalist* 120(1): 113]. I liked the high quality of these illustrations by John Gale and Brian Small then, and I still do now. They have proven to be of great value in the field as my now wrinkled *Birds of East Africa* will attest.

The range maps show the distributions as different colours and shading [resident, visitor, etc.] and they also have the highlands and major rivers. While this is useful, it is a little more difficult to read, especially for birds of limited distribution [e.g., the African Crake]. For the most part, I like this addition. Certainly it is clear that the highlands are more species-rich than the coastal lowlands.

Although we usually identify new birds using the illustrations, it is often the text that clinches the decision. The text in this book provides valuable insights into all species, but is a particular help in separating difficult, look-alike species. This is very important for birds like larks and pipits, even more so when dealing with endemics like Archer's Lark. The authors carefully evaluate the likely subspecies that might be present so they can accurately assess the differences between similar species.

The thousand plus birds covered include all the single specimen records, even those washed up dead on the beach. The authors list dubious and unaccepted sightings as well. All birds, even the vagrants, are given full coverage – complete illustrations and text. Despite this large number of species the book is not oversized, it will still fit in your pack.

Now comes the critical question; Who is the intended audience? There are tours advertised for this area and some British companies have regular trips to Ethiopia, despite their Foreign and Commonwealth Office advising against ALL travel. There are travel advisories from U.S. and Canada too. Ethiopia has suffered drought, famine, war, and bad governance. A 31-year war gained independence for Eritrea in 1993, but this led to border war. Somalia [and the unrecognized Republic of Somaliland.] does not have an effective government and has had years of fighting between rival warlords. As well, fighting has occurred between Islamist fighters and the interim government. Poverty has spawned pirates and illegally dumped nuclear and toxic waste. Djibouti was ravaged by a civil war until 2000. This is not a comforting situation for the prospective traveller. You will have to be more than a little adventurous. There are wildlife groups in Ethiopia, Somalia and Yemen. Yet with average incomes around a few hundred dollars a year, I do not see a large local market.

It is sad to reflect on this poor political situation is stopping the flow of ecotourists with their much needed cash, because now there is a top quality field-guide to the birds of this diverse region. In addition to the 61 endemics and 17 near-endemics [tabulated at the rear of the book] you can look for most of the birds from the south [Kenya], from the north [Egypt] as well as Eurasian migrants. A well-organized trip of two weeks will net you 500 or more species. This is a good book and more important, it is a landmark book — covering a long-neglected area. I hope it does well.

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## The Frogs and Toads of North America: A Comprehensive Guide to Their Identification, Behavior, and Calls

By Lang Elliott, Carl Gerhardt, and Carlos Davidson. 2009. Houghton, Mifflin Harcourt, Boston, Massachusetts and New York, New York, USA. 344 pages. USD 19.95.

This is a mini coffee-table book, 8 ½ inches (20.6 cm) high and 12 inches (22.9 cm) wide, an unfriendly size for a bookshelf, but great for spreading open on the table. It focuses largely on two aspects of breeding North American frogs (in the broad sense, inclusive of all Anura, the tailless amphibians): their appearance and their sound. It is sumptuously illustrated with sharp, vivid colour photographs which vary from column, to half page, to full-page width, a treat to the eye at any size. These depict adults in sedentary rest or calling positions, with a sprinkling of pairs in amplexus. There are two of spectacular mating "knots" of Western Toads (page 24) and American Toads (page 317). The only eggs and tadpoles featured are part of a representative life cycle diagram (of the Wood Frog) by Cindy Page (page 17). All 101 species of anurans (97 native and 4 introduced) found North of Mexico are included in photographs and text. Also included is a CD of recordings of vocalizations of 99 of these (the two species of mountain stream dwelling tailed toads are missing because they are mute). Most calls are distinctive at least for groups, but the second last presented, the Mexican Burrowing Toad, will most effectively startle even most veteran herpetologists who have never heard it. Advertisement (mate attracting, both singly and in chorus), territorial (rival male inhibiting) calls, protest notes (given largely in same-sex encounters) and fright screams (reaction to disturbance, particularly when grabbed by a predator) are included. A detailed "Compact Disc Track Descriptions" (pages 324 to 335) gives species, locality, and (usually) time and air (?) temperature for each segment. Almost a quarter (24) of the species covered occur in Canada. Three are represented by recordings taken in Canada (Western Toad at Edmonton, Alberta; Canadian Toad at Wood Buffalo Park and Edmonton, Alberta; Boreal Chorus Frog from Riding Mountain National Park, Manitoba), and a few others are from adjacent United States localities in New York in the east and Washington in the west.

The authors have a mix of backgrounds. Lang Elliott is styled as a recordist, writer, and photographer who has authored several previous book/CD packages including ones on insect and bird sounds. H. Carl Gerhardt is a herpetologist with more than 120 publications mostly emphasizing vocal communication, particularly in frogs, and is a professor at the University of Missouri. Carlos Davidson is a conservation biologist, with a background in ecology and economics, and is the director of environmental studies program at San Francisco State University.

The text begins with a foreword by Joseph T. Collins who stresses that the continued seasonal noise from aquatic breeding anurans is a signal that water still

exists around us. Silence would likely mean it was gone or undrinkable. This is followed by an authors' introduction characterizing the book as a celebration of the primeval and enchanting vocalizations of frogs. Brief sections discuss classification (picturing the nine family groups included), their natural history (life history, water loss and activity patterns, the challenge of being cold-blooded, diet, defence against predators, amplexus and fertilization, egg-laying and hatching, vocal communication, vocal repertoire, mating systems, female choice, sound production, energy requirements of calling, hearing), evolution and speciation (with a heavy bias for examples from treefrogs, the subject of many of Gehardt's publications), modes of speciation, contact zones, conservation issues (causes of amphibian declines and deformities), miscellaneous explanations (the disc, the range maps, lengths, ordering [sequence] of species, number of species, naming of species), and a species and track list of pages for accounts and numbers in recording sequence.

The bulk of the book is species accounts. Each group is introduced by a one-page family account and photographs of a typical member, followed by one-page account and one to three pages of variants of each included species. The accounts start with an introductory paragraph, a range map, and sections on appearance, range and habitat, behavior and voice. The text statements are unreferenced, but have the ease that indicates a great deal of first-hand field experience. The problem of recent unfamiliar generic name changes for some widespread North America frogs and toads is neatly, if uncourageously, solved by putting the long standing name first and the amended one in parenthesis after. The maps are drawn primarily from the U.S., National Amphibian Atlas ([www.pwrc.usgs.gov/naa](http://www.pwrc.usgs.gov/naa)) supplemented for Mexico and Canada by the Peterson Field Guides to eastern and western North America and various local sources. A surprise was the occurrence of the Red-legged Frog, *Rana aurora* in southern coastal Alaska (perhaps as a result of introductions?) depicted as disjunct from its British Columbia populations in the southern mainland coast and Vancouver Island. Partly due to the scale of the maps, Canadian ranges are often carelessly indicated and a common error is repeated from earlier guides in the depiction of distinct separate ranges in southeastern Manitoba, Minnesota and the Dakotas for the toad "species" *Bufo* [*Anaxyrus*] *americanus* and *hemiochrys*. This pair, wherever studied adequately, appear to interbreed freely where they contact and form populations that are hybrid swarms of intermediates.

A section on finding, observing, catching, and keeping, includes the important caution that finding out current local or provincial laws and obtaining required

permits is now essential in most, if not all, areas of the continent. It still is OK to listen and watch in most as long as it does not involve trespassing on private property without permission, but disturbing of animals or habitats is increasingly discouraged. The concluding sections cover the making of the book, acknowledgments, and credits for the photographs, the sound recordings, compact disc track description (mentioned earlier), sources and a sparse list for further reading (five field guides, four reference works, one on keeping frogs and toads as pets, six nonprofit and governmental websites, three volunteer monitoring programs (including Frogwatch Canada), regional websites,

and three audio guides. Finally, a five-page index to species and groups concludes the book.

As a visual and auditory introduction to frogs, toads and their kin in North America, this book is outstanding. It would be a useful and relatively inexpensive addition to any reference shelf, a conversation starter on any coffee tables and a treasured gift for any nature-appreciative and inquisitive relative or friend.

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## Shorebirds of the Northern Hemisphere

By R. Chandler. 2009. Andrew Isles. Natural History Books, 115 Greville Street Prahran 3181 Australia. 448 pages, 90 AUD Paper.

## Shorebirds of North America, Europe and Asia

By R. Chandler. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 448 pages, 35 USD Paper.

I believe these two books are the same although there are differences in the press releases (850 vs. 700 photos, 134 vs. 135 species covered) provided by the two publishers. I think one is the European version and the one I have from Princeton is the North American. [Do not confuse this book with the 2006 *Shorebirds of North America, Europe, and Asia: A Guide to Field Identification*, by Stephen Message and Don Taylor and also published by Princeton.]

That being said, this book has the wow factor. At your first flick through you will see a mass of wonderful photos. After I had finished my initial ogle, I settled into a more systematic review.

The book starts with a section on plumage that is far more detailed than the typical introduction. It is also illustrated with examples of the feather developments. This is followed by a similarly-styled discussion of shorebird behaviour.

The species accounts cover jacanas, Painted Snipe and Crab Plover, oystercatchers, Ibisbill, avocets and stilts, thick-knees, Egyptian Plover and coursers, pratincoles, ringed plovers, small plovers, *Pluvialis* plovers, lapwings, sandpipers, snipe, dowitchers, woodcocks, godwits, curlews, *Tringa* sandpipers, turnstones and phalaropes. This is a little different order than normal, but this does not detract from its use as a reference book. Each species has a thorough explanation of all plumages: juvenile, adult (breeding and non-breeding) and any racial variations. There is a description of status, habitat and a range map of summer, winter and permanent distribution.

Each account has several quarter to half page photos showing the various plumages described. There are some full-page photos too. All of the photos are lovely, crystal clear portraits of birds in habitat or feather

details, including definitive flight shots. Most of them are by the author with additions from many other sources. These photos show more detail than can usually be seen in the field. For example, the Wilson's Snipe uses two tail feathers in its display as compared to the nearly-identical Common Snipe which uses one. This diagnostic feature is difficult to see on a swooping bird. I might try photographing the next displaying snipe I see, just to discover if I can pick out these feathers. [In 12 pages of Internet pictures there was only one flying Wilson's Snipe and its tail was closed]. You can see the variations in the various snipe superciliums very easily, unlike in the field.

Despite the use of North American term Shorebirds in the titles rather than the European Waders, the author uses European names throughout. Where there is an alternative name [Grey vs Black-bellied Plover] this is noted. Species splits are current [all the "golden" plovers for example. I did not have any issues with the range maps and distributions. Personally I have found the Yellow-wattled Lapwing rather hard to find and not "fairly common," but that is not valid basis for comment. Not included in the species accounts are Eskimo Curlew and Black-fronted Plover, as there are no current reliable records for the region covered.

Personally, I think this is a "must have" book for the serious observer. While many shorebirds are showy and easy to identify [avocets] others are a perpetual challenge. I wonder how many Little Stints have been overlooked in North America? Or Eurasian Oystercatchers? This book will provide a very handy reference and, one I am sure, I will be using frequently from now on.

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Book Review Editor's note: Continuing with our decision to investigate suitable websites and, if appropriate, include their reviews. I have written the following review at the suggestion

of Sandy Garland. If others know of similar suitable sites and are moved to submit a review please contact me at [r.john@rogers.com](mailto:r.john@rogers.com).

## The Nearctic Spider Database

By Database administrator, David P. Shorthouse ([dshorthouse@eol.org](mailto:dshorthouse@eol.org)). 2009.  
[http://www.canadianarachnology.org/data/canada\\_spiders/](http://www.canadianarachnology.org/data/canada_spiders/)

This database covers Greenland, Canada, the United States, parts of Mexico, and Bermuda and states that this area includes 70 families, 674 genera, and approximately 4500 species of spiders. The contributed specimen records to date amount to just over 2000 species. The species pages are peer-reviewed [three reviews] accounts voluntarily written by araneologists and museum curators. This is not a government-funded operation, but is supported by enthusiasts willing to give their time. This also means there are no political or financial limitations. However, the database will only thrive and grow if enough participants are willing to contribute. So far there are 243 either completed or draft "species pages."

The author uses "Unique species" to indicate that he has had to reconcile some names to construct those regional tables. If the specimen record uses a synonym or old treatment of a species' name, it is lumped into an aggregate of other specimens whose nomenclature is the currently recognized nomenclature.

I tried the "Species List by Nearctic Region" which covers all provinces and states [except Vermont and Rhode Island] and plus Greenland, Mexico and Bermuda. By clicking Canada I can see the database contains 575 "unique" species against an expected 1375 or 42%. For Ontario there are 156 species against an unknown expected number.

Going to the Ontario section I get a list of the 156 species. Choosing number 20 I reach the *Argiope trifasciata* page. This gives the common name as Banded Garden Spider, a map that shows a distribution along much of southern Canada, a description of habitat and a beautiful photo of the lovely species. Some of the sections are marked as "unrecorded or unknown." There is a substantial reference section.

Moving to the *Argiope aurantia* [Yellow Garden Spider] page there is a similarly lovely photograph and the same level of information as the previous species, plus line drawings giving male and female dimensions.

The data can be accessed in a number of ways: by province or state, by species, by descriptions or by images. On 23 May 2006, in Ottawa I saw a spider about 1.5 cm long, very compact with thick limbs, the front was shiny, polished black and the abdomen was soft buff with a dark brown centre stripe. With John Acorn's help I identified it as *Phidippus johnsoni* – the Johnson jumper. I tried the database's search mechanism for *Phidippus* and *Phidippus johnsoni* and it worked very well. There is a very fine photo of this impressive species. I was surprised, however, to find

*Phidippus johnsoni* is not listed for Ontario, only in Alberta and British Columbia. If this is a new record I unfortunately have no proof, as I was going down the highway at 100 km/h with the spider running back and forth along my dash before jumping to my knee and disappearing!

Nothing is mentioned of the venom hazard from *Latrodectus mactans*, the Southern Black Widow, nor *Latrodectus variolus*, the Northern Black Widow. This latter species is not shown as being in Canada. Even more odd *Latrodectus bishopi*, the Red Widow, who's range is given as "USA" only, whereas the Bug Guide [<http://bugguide.net/node/view/15740>] says it is found primarily in sand-pine scrub habitats in central and southeast Florida, specifically from Marion County to Martin County. [Other useful websites are <http://www.spiderwebwatch.org> and <http://forum.canadianarachnology.org>]

There is a useful glossary of spider terms.

It is soon clear that there is much to be learned about our spiders at all levels. I noted that three species are listed for Nunavut and 27 for the Northwest Territories. This, I am sure, can be attributed to much better access [by scientists] by road, water and rail. Similarly Alberta's 416 species vastly outshines Saskatchewan's 45 and Manitoba's 46. There are numerous gaps at all technical levels. Only a portion of the species are illustrated and not all of these are field photos [some are of museum specimens]. The most information is on the common species like *Araneus diadematus*, Cross orbweaver, which I know as that long-time, plump friend the Garden Spider.

One obvious lack is the absence of a common name for many species. Several years ago the dragonfly enthusiast began developing common names for the odonates as a way of raising their popularity. Maybe this needs to be done for spiders too!

The Nearctic Spider Database is another very useful tool for amateurs and professionals alike. It will clearly grow and increase in value with time. It opens a door for serious contributions in many areas of spider biology. My grandchildren repeatedly "squirt" me with spider web in imitation of Spiderman. Recently I suffered the same two-finger "fate" in Niuaotupapu, a remote island in Tonga – so Spiderman has huge influence. Surely there are some new araneologists in the making in this world!

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## Super Suckers: The Giant Pacific Octopus and Other Cephalopods of the Pacific Coast

By James A. Cosgrove and Neil McDaniel. 2009. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0. 208 pages. 26.95 CAD Paper.

As a young boy I haunted the Natural History Museum on Cromwell Road in London, England. One of the many fascinating exhibits was the shell of the Chambered Nautilus (*Nautilus pompilius*). Next to the whole shell was one cut in half, exposing the remarkable chambered interior. I always coveted this beautiful object and a specimen now graces my living room.

This book covers the nautilus and its cousins, squids and octopuses, in some detail. Most of the book, however, concentrates on the North Pacific Giant Octopus (*Enteroctopus dofleini*). This creature has a fascinating, if short [four year], life history. The authors cover its sex life, egg laying and early planktonic life.

Octopus have some amazing abilities. They can change the colour and texture of their skin in a flash. They can envelope their prey in a numbing toxin. Their suction cups ranked along their arms [octopus do not have tentacles, but squid and cuttlefish do] are immensely powerful. Octopus can squeeze their large bodies through impossibly tiny holes, making them the animal Houdini.

After introducing us to some myths [interesting ones from the native community and fanciful ones from Hollywood] the author presents an overview of molluscs. Then he focuses in on the biology of the Giant Octopus; how it lives, breathes, eats and reproduces. Because it is so different from terrestrial animals, this is an absorbing account.

One fascination with the Giant Octopus is how large does it get. Certainly ones over 70 kg are proven, but as not many people took accurate defensible measurement some big ones may have "gotten away" – at least from the record.

The authors spend some time exploring the intelligence of the Giant Octopus. The problem, of course, is how to measure brain power of a creature that is so fundamentally different from us. Numerous research-

ers have tried and, while none have come up with an absolute answer, it is clear this beast is a smart creature. It can solve problems that would confound a three or so year old human.

The other cephalopods are covered, better than I have seen elsewhere. The squid species are clarified as is their status in the North Pacific. It is obvious, however, the authors' first love is the Giant Octopus, and maybe rightly so.

The photographs, many by Neil McDaniel, are very good. Having tried underwater photography for the first time earlier this year, I have a new appreciation for undersea photographers. On land only the subject might move, but in the ocean both the photographer and the wildlife are moving all the time. Unlike land animals fish often swim too close as well. Neil and his colleagues have given us some remarkable and colourful underwater images of many curious creatures.

The book is written in a lively, anecdotal fashion that is easy to read. In fact, I wondered who the authors saw as the audience. Sometimes I felt this was a book for teenagers and at others it seemed more adult. It was repetitious, even to the point of using virtually the same text. The authors often use text boxes for important points; a great idea, but this is where much repetition occurred. There were also explanations of "scientific terms," again a valuable addition for words like "chemotaxis." I am not convinced that adults need a definition of "enzyme", although teenagers might.

Overall the book is fun to read, about a species and its kin that are not well understood by most people. It is nice to realize the truth is more amazing than Hollywood's fantasies.

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## The Second Atlas of Breeding Birds in New York State

By K.J. McGowan and K. Corwin. 2008. Cornell University Press, Sage House, 512 East State Street Ithaca, New York 14850, USA. xxiii + 688 Pages, 59.95 USD, Cloth.

We are now well into the era of second atlases of breeding birds; a few have recently come out (Ontario, Alberta) and others are currently in the field stage (British Columbia, the Maritime provinces). Atlases of today are not only known for reporting the breeding distribution of birds, they are also known for documenting avian history and basic biology as well as presenting stunning photographs or artwork of the area's birds. This second atlas of New York's birds is very representative of what we've come to expect of contemporary atlases, and it is a very welcome update on the breeding birds of that state.

One's first impression of the book is the stunning artwork. Each species account is accompanied by a pencil drawing that is much more than just a profile shot. The artwork spans all facets of birds' lives, from incubating and nest-building, to courtship displays and feeding. The most elegant of these to my eye were the combative King Rails (Alan Messer), Northern Shoveler (Sue deLearie Adair) and Great Blue Heron (John Perry Baumbin), the latter of which also ended up engraved on the book's cover. Prior to each group of birds, there is a two-page colour spread illustrating one to several of the species in a typical, though not nec-



essarily natural habitat. These paintings are all well done, and range from a Great Blue Heron flying in an ethereal mist (Michael Ringer), through the comforting forest with owls (Daniel Meyer) and the placid farm fields with blackbirds in the hedgerow (Bull Riley). Some of these two-page spreads include birds which are so cryptically included that only the caption alerts you to their presence – nice touch. The mislabelled American Oystercatchers (as Black Skimmers) should have been caught at some level of the editorial stage.

As with most atlases, there are introductory chapters (six in this case) which provide context for the species accounts. The methods by which the project was carried out, and presented in the book, are quite well explained; a series of 15 maps illustrate everything from urban areas, drainage, forest types, and Bird Conservation Regions. Instead of reporting birds in 10×10 km squares, 5×5 km blocks were used, which gives a higher resolution to the distribution maps. The extra effort to do this was, I assume, not trivial, and will likely result in better management decisions by users of this book. Results are summarized in the opening chapters, with two tables comparing the species detected in this project with those of the first atlas from 20 years prior; one is arranged taxonomically, the other by degree of change – nice. Summary maps illustrate species richness per survey block as well as a comparison of richness between the two atlas projects. All in all, this is a well-done section, explained with enough detail to satisfy statisticians, but not so overwhelming as to disillusion the non-specialist. A liberal application of photographs, especially in the chapter on habitats, would have made for much greater visual appeal, and understanding of the introduction to this book.

Other atlases have included other introductory chapters ranging from aboriginal use of birds to a summary of other bird survey data (e.g., Christmas Bird Count, Marsh Monitoring, etc.). I assume it is a difficult choice for the editors to come up with the right breadth and amount of material – every additional chapter represents more people to deal with and more cost to the project, and hence a higher retail price. I wasn't disappointed with the selection though I would have liked to see a chapter on the state's birding hotspots (perhaps the top ten), complete with a state map showing their locations and perhaps a paragraph or two on, and a photograph of, each.

Maps are key to any atlas, and I found pros and cons to their use in this book. Positioning the major non-distributional maps (e.g., political borders, topography and eozones) on the end sheets was great. This provides the reader with ready access to this information. As my old geography teacher once told me (ok, he had to tell me many times), "no province [or state] exists in isolation", so at least the political map of New York should have had neighbouring states, provinces and water bodies labelled. Less-often used maps ("des-

criptive maps"), such as human population distribution, precipitation and bird conservation regions are appropriately slotted in the introductory chapter, though all the end-paper maps are repeated there, too – unnecessary, in my mind. There are three maps misplaced in the summary results chapter – these maps show effort by birders in surveying squares, and given that *effort* is not a result, but part of the methods, those maps should have gone in the methodology chapter.

Each species account has two maps. The first shows distributional data for the second atlas, with squares of different shades indicating degree of confirmation. The second map compares the species' distribution from the current project with that of the previous one. It's not clear why the two maps weren't combined using the dot-in-a-square approach used successfully by other atlases, including the recent second Ontario Atlas (Cadman et al., 2007). In doing so, more space for other population indices (see below), embellished text, or a photograph would have been available.

Although a comparative look at the two maps gives a feeling for the level of breeding conformation and change since the first atlas, the editors have also chosen to include a small table giving some raw numbers and percentile changes. Although this feature won't be the first bit read by most users, I think it was a useful addition.

Although more than forty authorities were responsible for authoring the species accounts, over half were written by Kevin McGowan, one of the book's editors. There wasn't one account that wasn't well written or edited. I think putting headings (status and worldwide distribution, trends in New York, etc.), would have been useful. The species accounts start with a history of the bird's presence in the state, including a detailed comparison by the results from the state's first atlas. I was a bit confused with the following reference to the Ring-necked Pheasant: "Future land-use changes – will pose serious challenges to sustaining wild populations of this popular game bird." As someone who stands firmly against introducing species, let alone "sustaining" them, I found this comment just wrong.

A bird atlas should be about more than the results of *atlassing*, per se. The goal is to describe the distribution and numbers of breeding birds, and there are a multitude of surveys that could have been utilized to supplement the information. Although Breeding Bird Surveys were used for appropriate species, very few other data sources were utilized. Christmas Bird Count data were used for sedentary owls, but why not use them for other non-migratory species? It would have been very interesting to compare the CBC data with those of the BBS for Downy Woodpecker, House Finch, and Ruffed Grouse, among others.

I feel that the major omission in this work is the lack of point counts. Although early atlases did not use point counts, more, such as Ontario and Pennsylvania, which have completed their field work (with the

latter still to be published) do so now; British Columbia and the Maritimes are both using point counts in their current protocols. These will establish a baseline of species' abundance that can be used to compare with subsequent efforts.

Overall though, this is a very well-written and illustrated book that will not only inform about current and past breeding distribution, but give some basic biology of New York's birds as well.

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### Birds of Europe, Russia, China and Japan: Non-Passerines Loons to Woodpeckers

By Norman Arlott. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 240 pages. 29.95 USD. Paper.

When I received the first volume [or is it the second?] companion book [*Birds of Europe, Russia, China and Japan: Passerines*] my wife and I were due to visit China and Mongolia. This trip was cancelled due to earthquakes and a Muslim insurgency. Just as we decide to revive our trip to China [by sea, with stops in Japan and eastern Russia] this second book makes a timely arrival.

Between the two guides Arlott covers approximately 1800 bird species in Europe, Asia north of the Himalayas, Africa north of the Sahara Desert, and the Middle East excluding the Gulf countries. This new volume covers seabirds, ducks, shorebirds, gulls and terns, raptors, owls, swifts, hummingbirds, cuckoos, and pigeons. Despite the author's statement that he has covered all the birds recorded up to early 2008, I immediately noticed that the White-eared Night-heron *Gorsachius magnificus* is missing. It is found in China [and Vietnam] and numbers less than 1000 so is not likely to be seen by a visitor. Also Formosan or Taiwan Blue Magpie (*Urocissa caerulea*), an endemic bird from a small area in the mountains of Taiwan, is missing. More important to me, however, is the good coverage of seabirds along the China-Japan-Russia coasts. However, this also points out the one real failing of these two books. The adult, white-and black, short-tailed Albatross is nicely illustrated from above and below, but the all brown juvenile [and the one that could be confused with a juvenile Black-footed Albatross] is not shown. I think we must accept this in books that cover 1800 species and, combined, are two thirds the size of my Sibley's [The Sibley Guide to Birds, by David Allen Sibley, National Audubon Society, which covers only 810 species]. Generally it is only adult plumages and all but the raptors, seabirds and swifts are not shown in flight. These details are most significantly missing in the gulls. Here wing patterns and the sequence of moults are very important.

Norman Arlott, a leading and experienced bird artist has illustrated and described the adult plumage of the non-passerine birds of this region. As before, the illustrations are top quality and, in this book, the printer has

achieved better quality control. The European Bee-eater is a good example as it has both the correct hue and saturation ["colour" and "depth of colour"]. Cramming together so many species has led to some proportional errors. For example, the Rufous Hummingbird is 30% bigger than it should be compared to the African Grey Hornbill on the same page. Once I realized this, I looked at other illustration more carefully. I noted several species are not quite to scale. For example the Gyr Falcon is a mere 14% bigger the Peregrine next to it, when it should be twice that. Similarly, the Cape Pigeon should be larger than the neighbouring Murphy's Petrel.

There is one page that covers eight species of snipe and two woodcocks. While Arlott has depicted the minute differences accurately [in, for example, the width of the supercilium] and he does give basic differences in the text, it would be hard to use this plate in the field. Therefore I would not recommend this book for beginners. People with experience or novices with a more detailed text [like Sibley's] will find it a splendid reference. I look forward to using it in the fall. It will jog my memory of details about such birds as Slaty-backed Gulls, Wedge-tailed Shearwaters and Oriental Turtle Doves.

I used the mask I created for the first book [Made from a piece of clear plastic sheet with the outline map traced in blue, and I added transparent green to cover the region I now plan to visit.] By placing the mask over each map and I can quickly see if I will be in any bird's range. The range maps are 2" x 7/8" [5 x 2 cm] and again cover from Britain to Kamchatka, from Svalbard to Northern India. I have found this to be a rewarding exercise, especially for the open sea of the north Pacific — an area seldom visited by birders. It will be interesting to see how well my predictions work out. In particular, the range map for Lesser Black-backed Gull shows a winter distribution on the coasts of southern Japan and China. This is not supported by any other publication. It could be that Arlott has included the range of a bird once considered a sub-species of Heuglin's Gull as "*Larus heuglini taimyrensis*." This



Lesser Black-backed Gull-like bird is now considered a hybrid of *Larus heuglini* and *Larus vegae*. This controversial bird winters in very small numbers in the area depicted.

So once again I believe Princeton has published a very useful guide for the traveller. This book may not

be ideal for all birders, but for those of us who have to be concerned with weight and size, this compact volume is a gem.

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## Carnivores of British Columbia

By David F. Hatler, David W. Nagorsen, and Alison M. Beal. 2008. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2 Canada. 416 pages. 27.95 USD.

*Carnivores of British Columbia* is the fifth in a series of six books to replace and update the 1964 handbook, *The Mammals of British Columbia* by Ian McTaggart-Cowan and Charles Guiguet. The first four of the series cover (1) bats, (2) opossums, shrews, and moles, (3) hoofed mammals, and (4) rodents and lagomorphs. The sixth volume will cover marine mammals.

This well-researched volume covers 21 carnivores that occur in British Columbia. The carnivore families presented include the canids, ursids, procyonids, mustelids, and felids. Although carnivores as well, the five species in the Phocidae (haired seals) and Otariidae (eared seals) families will be included in the marine mammal volume.

The book begins with a general biology section that discusses why an animal should belong to the Order Carnivora – a central theme in the ecology of the carnivore group as a whole is the procurement of food by predation. Unique features that set carnivores apart from other mammals include canine and carnassial teeth, relatively heavy skulls with strongly developed facial muscles, and clawed digits on each foot. Carnivores tend to travel widely in search of prey, search out new territories, and other activities that require long ventures. Carnivores have keen senses and large brains, needed to help track down food, as well as to avoid danger and interaction with other species. The general biology section also covers resting and den sites, movements, home range and social behaviour, reproduction, mortality, health, and longevity.

The biogeography of British Columbia is included to provide the reader with the geographic background and a required land mass orientation lesson on the distribution of British Columbia carnivores within the 10 ecoprovinces. The first table in the book provides a handy reference where the reader should expect what carnivore species is in what ecoprovince. Some species, such as the coyote (*Canis latrans*), occur in all 10, but others, such as the sea otter (*Enhydra lutris*), occur only in one (but may have a minor occurrence in another). Following the general biology section is a checklist of species, an identification key, and a skull key.

The species accounts for the 21 British Columbia carnivores follow the same order as the checklist, which is on pages 41 and 42. Each account includes a drawing of the animal and the skull. Each account is tailored to British Columbia, making the information relevant for that specific geographic region. If a particular ecological aspect of a British Columbia carnivore is not well researched, information about that carnivore from other studies outside of British Columbia is used to fill the data gap. The information in the species accounts is divided into nine sections: (1) other common names, (2) description, (3) distribution and habitat, (4) natural history, (5) human uses, (6) taxonomy, (7) conservation status and management, (8) remarks, and (9) selected references. These sections provide an adequate and comprehensive ecological study of the species, and are a result of more than 40 years of research published in peer-reviewed journals, and other sources. Each account has a distribution map specific to British Columbia showing both museum and harvest records, and throughout most accounts are other relevant black-and-white photos. For example, on page 117, there is a picture of black bear (*Ursus americanus*) claw marks on a poplar trunk, showing the reader what might be encountered in the field.

At the end of the book is an appendix listing the scientific names of organisms mentioned in the book, as well as a glossary, and a list of references. Overall, the book is well organized and written. Unfortunately, the handbook does not have a colour plate section showing the 21 carnivore species, although publication costs were the likely reason it was not included. *Carnivores of British Columbia* is an excellent addition to the six-part series, and anyone interested in the carnivorous mammals of British Columbia will be in good hands with this volume.

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## Handbook of the Mammals of the World – Volume 1: Carnivora

Edited by Don E. Wilson and Russell A. Mittermeier. 2009. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 728 pages. 230 USD, Cloth.

The *Handbook of the Mammals of the World* (HMW) is a new and ambitious project from Lynx Edicions which is currently producing the *Handbook of the Birds of the World* (HBW) [Currently at Volume 14 out of 18]. This will be a series of eight volumes and it will describe all the currently recognized 5000 or so mammal species. As with HBW, there will be an overview of each mammalian family before the species accounts. Each volume will present the taxa in phylogenetic order and will include only those species that exist or have become extinct since 1600.

There is an account for each of the currently recognized species by the leading mammalogists of the world. Each account includes sections on Systematics, Morphological Aspects, Habitat, General Habits, Communications, Food and Feeding, Breeding, Movements, Home range and Social organization, Relationship with Humans and Status and Conservation. All species are illustrated and numerous photographs supplement the art work. The forthcoming volumes will cover Hoofed Mammals, Primates, Sea Mammals, Marsupials, Rodents, Insectivores and finally Bats.

The first volume introduction is on in the most fundamental terms. The various forms of the skeleton are colour coded so you can follow a single bone into its various formats – fox foot, dolphin flipper, bat wing and so on. Then you see how this translates into motion. The internal organs get a similar treatment, especially the reproductive system that helps define our mammal nature. This includes the mammal link to reptiles, the monotremes, and Australia's contribution: the marsupials.

This first volume covers the Carnivores – cats, dogs, mongooses, weasels and bears. These are some of the most appealing animals in the world. On the first page is a dramatic portrait of a Snow Leopard by Robert Batemen. The family introductions include many truly appealing photographs, not only of the most gorgeous mammal [at least in my opinion] – a baby Polar Bear, but many of the “poster boys” – Sea Otters, Pandas, Meerkats, Tigers and so on. These photos range from great to glorious. Nothing could be more appealing than a mother Polar Bear nuzzling her cub.

Each species account starts with an illustration plate of the “average” appearance of that mammal. If we look at the common, widespread and relatively easy to see [I have seen six in the first eight months of 2009] Red Fox, there are three colour phases. In my life I have seen all three, but this year I saw four reds and two that were half way between red and black. I think we need to remember that how a mammal appears is

dependant on many factors, not the least of which is genetics, diet and health. Some poor foxes I have seen are not “red”, but a sad mangy brown. You cannot expect this colour variation to be included in this type of book; but you need to make this allowance in the field. Such variations are covered by the text. In reading the account for Striped Skunks I discovered that brown and even red animals have been seen.

The descriptions are thorough, giving coverage of different morphs like the “glacier” and “cinnamon” versions of the American Black Bear. There is similar coverage of the various Brown Bears around the world. In reading the Gray Wolf account I was surprised that there was no mention of the recent molecular studies that have shown the Eastern Wolf is a distinct species (*Canis lycaon*) and not a subspecies of the Gray Wolf. Equally surprising, there was no mention of the work done by John and Mary Theberge and their 14-year study of wolves in Algonquin Provincial Park. This study continued the wolf research of Douglas Pimlott, also not mentioned. The Theberge study resulted in a book and 22 scientific papers, enough to capture someone's attention. The Dingo is also now considered a subspecies of the Grey Wolf as is the domestic dog [*Canis lupus familiaris*].

Some years ago I had excellent views of a Patagonian (Red) Fox. I could not find this species in the index and eventually worked out it was listed only as the Culpeo (*Pseudalopex culpaeus*). It is sometimes called the (Common) Andean Fox in the proposed genus *Lycalopex*, so it seems the taxonomy needs work.

The text on other species, such as the Tiger, is well-balanced and informative. The distribution, subspecies, diet and the conservation status are covered in concise terms. In the case of the Tiger the complex issues of parts for medicine, habitat protection and prey species are all raised. Incidentally the artist has captured the intense “stare” that only a Tiger can give in the illustration of *Panthera tigris altaica*.

If you are excited by the fluid of the Yellow Mongoose, the butterfly ears of the Bat-eared Fox or the antics of a Golden Jackal then this is the book for you. If you seriously want to find and see mammals then this will help. If you simply enjoy beautiful books, here is one for the wish list. Lynx are to be congratulated on beginning what will eventually be the reference work for the Class Mammalia. This is a must-have book for all those with an interest in mammals.

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## Suburban Howls: Tracking the Eastern Coyote in Urban Massachusetts

By Jonathan Way. 2007. Dog Ear Publishing, 4010 W. 86th Street, Ste. H, Indianapolis, Indiana 46268, USA. US \$23.99 plus shipping and handling via [www.easterncoyotereseach.com](http://www.easterncoyotereseach.com).

Here is a fabulous journey into the life of the eastern Coyote in the northeastern United States. If you've ever wanted to know these canine inhabitants of wildlands and rural and suburban zones better, this book is for you.

Author Jonathan Way started studying Coyotes when he was in high school. *Suburban Howls* encompasses his life and studies beginning then, and continuing through his university years to the present. He is a scientist who loves his subject, loves the very beings of his subject.

Way's presentation of his studies, largely through radio collar tracking and observations, is densely packed with different kinds of information. He takes the reader into the field to watch Coyotes leading their lives, then through the trials of trapping, measuring, collaring and tracking. We experience the very frustrating process of trying to get study permits from government agencies, and confront the challenges of loving and studying an animal that others would happily shoot in numbers. We share the author's grief and consternation when a whole group of his wild study animals are poisoned to death by rodenticide. We're invited to wonder how his grandmother felt when he temporarily moved five Coyote pups into his basement apartment in her home.

A large section of the book is devoted to Way's experience creating and studying a group of captive Coyote siblings in a zoo. Here we learn more about observed Coyote behaviour through the author's intense bonding with his subjects. We are given cause for reflection both about the ethics of this project, and on the poignancy of his eventual, permanent separation from the group.

The book is brimming with observations not only about Coyote ecology and behaviour, but also about wildlife management and politics, humans' perception of wildlife, and human behaviour. It includes black-and-white and colour photos showing both the coyotes and the author, often together.

Way treats his study Coyotes as individuals, taking great care to show their distinct personalities. He has

a fierce and obvious commitment to helping people appreciate, rather than fear and revile, Coyotes. I completely respect his determination to include his own emotions as he presents his work, as an intentional means to deliver a message. If I have one, tiny reservation about the book, it is that the author is perhaps too present, making it too emotionally rich for me. I found it difficult to read for that reason.

But that is a trivial complaint, related to a reader's taste rather than the quality of the book. The work is remarkable, thorough and heartfelt. It is a lively read. On the occasional attempts I made to skim through some parts, the author's story telling instead drew me in to read voraciously in spite of myself. I also admire Way's candour. He tells a straightforward story, not making apologies or excuses where other authors might. My favourite example is when he describes watching a Coyote contemplate making a meal of somebody's pet cat. The cat is at large in Coyote-land, taking its chances on the rough edge of town, but still — it's obvious Way doesn't intend to intervene. That is simply stated, with no rationalization offered. (The cat gets away, no doubt to make its own meal of some smaller wildlife.)

*Suburban Howls* is well designed and organized, complete with a table of contents, tables, maps and several appendices. The author includes a bibliography of his journal publications, and a thorough glossary and index. The book will be of interest to students of wildlife biology, wildlife management, and of human-wildlife interactions and ethics. It is definitely readable for a general audience with an appreciation for adventure and a curiosity for wildlife. If you know someone (cat owner or otherwise) who could benefit from feeling more at home with their neighbouring Coyotes, you might sneak this book onto their coffee table. Follow Way's work into the future via his Internet site: [www.easterncoyotereseach.com](http://www.easterncoyotereseach.com).

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## BOTANY

### Les Orchidées indigènes du Québec/Labrador [in French]

By S. Beausejour. 2009. Les Editions Nature, 645 Boulevard Manseau, Joliette, Québec J6E 3E7 Canada. 176 pages, 49.99 CAD, Cloth.

Also visit <http://www.orchideequbec.com/fra>

You may not initially buy this book as a field guide. It is so beautifully laid out you will buy it for its artistic value. The photographs are simply remarkable. Any one can get a nice photo a Showy Lady Slipper,

but to make a helleborine look as stunning as a commercial cymbidium takes great skill. The same can be said for most of the photos in this book. For example the *Goodyera pubescens* and *Platanthera dilatata*

are beautifully portrayed. Even the little green *Malaxis*, *Piperia* and *Listera* look good.

The author has used a dark background throughout, throwing the flowers into bright relief. The effect is dramatic and very artistic. I know how difficult it is to get photos of this quality. It must have taken a lot of time and patience and culling through many photos to pick the best. The left-hand page has a full frame portrait of a single flower for the larger species and an ultra closeup for the tiny ones. The right-hand page shows the plant in habitat. Overlaying these large photos are further vignette photos, a distribution map and text boxes.

Once you have ogled your way passed all the pictures, you should read the text. This has been written with care so that it provides the basic information you need, without compromising the layout. The species names are given in French, English, and Latin. So *Calopogon tuberosus* is called the Grass Pink, Swamp Pink or *Calopogon gracieux* [the French name sounds so much more elegant for this graceful flower]. A text box gives the origin of the scientific name, the flowering season, the size and the scent. The remaining text gives background on varieties, the species preferred habitat and its abundance. Fifty-one species in twenty genera are covered, starting with the charming *Amerorchis rotundifolia* and ending with *Spiranthes*. *Platanthera* has the largest representation. Generic distribution maps are also included.

There is a section at the back of the book which is largely a translation of the French text into English. Unfortunately this was not proof read by an English editor so there are some rather odd sentences. For example under *Cypripedium reginae* it says "As opposed to what said Marie-Victorin ..." instead of "As opposed to what Marie-Victorin said ...." [Brother Marie-Victorin championed the formation of a botanical garden in the City of Montréal in 1931, and wrote *Flore laurentienne*, the first botanical treatise for southern Quebec's indigenous species.] Similar problems occur in other parts of the text – Under *Epipactis helleborine* it says "From it was introduced ..." and under *Goodyera tessellata* the French *venimeuse* is incorrectly translated as poisonous. Despite these errors [presumably introduced by the author's English collaborator as the author speaks little English himself] you should have no trouble understanding the text [and you can always refer back to the original, better French].

Any person interested in Canadian wildflowers, Orchids in particular, will be delighted to own this book. It will make a superb present, as it is a joy to see and French text is pleasant to read. Gardeners and orchid growers and even people who are not into wildlife will still get a thrill from the photos.

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## The Rare and Endangered Plant Species in the Area of Three Gorges Dam

By Wu Jinqing, Zhao Zien and Jin Yixing. 2009. China Water Conservancy and Hydropower Press, I-D, Yuyuantan Rd (S), Haidian, Beijing, China. 280 pages. 128.00 CNY.

The Three Gorges Dam is a hydroelectric river dam that spans the Yangtze River in Sandouping, Yichang, Hubei, China. It is a man-made miracle, a jumbo construction at one and a half miles wide and more than 600 feet high. Its completion made a list of at least 10 world records, including the creation of a reservoir hundreds of feet deep and nearly 400 miles long. As the world's biggest producer of electricity from hydropower, its turbines are expected to create as much electricity as 18 nuclear power plants. However, the electricity generated by the large dam was not regarded as renewable by many environmentalists because of the social and environmental damage or catastrophes that followed the project. The dam has flooded archaeological and cultural sites, displaced some 1.24 million people, and is causing dramatic ecological changes, including increasing the risk of landslides, deforestation and water pollution, and the danger of extinction of some valuable, rare, and endangered species, a consequence of their living habitats being flushed. Although some preventive measures could have been taken to avoid further deterioration of the ecological, environ-

mental and geological issues, the future is not very optimistic, since some environmentalists predicted that the impacts caused by such a large dam located at a place with a history of geological fragility might be irreversible.

The Three Gorges area alone accounts for 20 percent of Chinese seed plants—more than 6000 species. Many precious plant species near extinction in the area of Three Gorges Dam are on the national-level protection list. Some of them grow within the area submerged by water when the reservoir is full, so their disappearance is assured by the dam. Some other species might have to face the hidden dangers imposed by the reservoir in that their reproduction patterns tended to be altered by the dramatic landscape change. The reservoir could also break up land bridges into small islands, isolating clusters of animals and plants. The effects of disturbance of the dam on the whole ecosystems could reverberate for decades. In the short term, these species might still be there, but in the long term, they may disappear. Thus, the biodiversity in this area is being threatened as the dam floods some



habitats, reduces water flow to others, and alters weather patterns and the reproduction patterns of some species. In this course, the rare and endangered plant species certainly stand in the breach.

Since the rare and endangered plant species in the Three Gorges Dam area are facing the danger of extinction, the protection and rescue of these species in situ or ex situ is becoming more and more imperative. To do this work more effectively, knowledge of these species is needed. The publication of the book *The Rare and Endangered Plant Species in the Area of Three Gorges Dam* is timely and meets the current and urgent demands. The book reflects the consciousness of responsibility of Chinese scientists in raising public awareness, providing information for presentations, and suggesting effective countermeasures for dealing with the problem of the rare and endangered plant species in the area.

The book is based on original data obtained from field surveys. The book includes accounts of 350 plant species in the Three Gorges Dam area, of which 288 were state-approved rare and endangered plant species, and 62 were recommended rare and endangered plant species. All these species are briefly introduced in terms of their biological and ecological characteristics, but with focus on a selection of 200 species. Chinese name, Latin name, geographical distribution area, morphological characteristics, habitat characteristics, modes of reproduction, category or status of rareness and endangeredness, value of protection, and the extent that they are affected by the Three Gorges Dam project, are detailed. Then appropriate protection measures are proposed. The book contains a total of 413 color photos of these plants including, for each species, 1 to 5 color photos taken at different growth periods. Some of these plant species are pteridophytes, belonging to the families such as Psilotaceae, Ophioglossaceae, Dicksoniaceae, Cyatheaceae and

Adiantaceae. Some are gymnosperm, belonging to the families such as Cycadaceae, Ginkgoaceae, Pinaceae, Taxodiaceae, Cupressaceae, Cephalotaxaceae and Taxaceae. Some are angiosperm, belonging to the families such as Saururaceae, Chloranthaceae, Juglandaceae, Betulaceae, Fagaceae, Ulmaceae, Moraceae, Aristolochiaceae, Polygonaceae, Caryophyllaceae, Nymphaeaceae, Eupteleaceae, Cercidiphyllaceae, Ranunculaceae, Berberidaceae, Magnoliaceae, Calycanthaceae, Lauraceae, Papaveraceae, Cruciferae, Bretschneideraceae, Saxifragaceae, Hamamelidaceae, Eucommiaceae, Rosaceae, Leguminosae, Rutaceae, Euphorbiaceae, Buxaceae, Aquifoliaceae, Celastraceae, Staphyleaceae, Aceraceae, Hippocastanaceae, Sapindaceae, Balsaminaceae, Rhamnaceae, Actinidiaceae, Theaceae, Tamaricaceae, Flacourtiaceae, Begoniaceae, Nyssaceae, Theligonaceae, Araliaceae, Umbelliferae, Primulaceae, Nyctaginaceae, Oleaceae, Scrophulariaceae, Plantaginaceae, Rubiaceae, Caprifoliaceae, Cucurbitaceae, Araceae, Liliaceae, Dioscoreaceae, Iridaceae and Orchidaceae. At the end of the book, the detailed list of the rare and endangered plant species in the Three Gorges Dam area which are listed in the Red List of China Species is attached.

The book was well written and there are few errors. Abundant illustrations help readers to easily understand the explanations. The book is suitable for professionals engaged in botany, forestry, geography and environmental resources and other related fields, as well as professional teachers, students and so on.

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## Common Wetland Plants in China

By Zhang Shuren. 2009. Beijing Science and Technology Press, 16, Xizhimen South Street, Beijing, China 100035, 286 pages. 75.00 CNY

As we all know, wetland is an area of land whose soil is saturated with moisture either permanently or seasonally, including all areas whose water depth does not exceed six metres. Wetlands are described as ecotones, providing a transition between terrestrial and aquatic ecosystems, making them inherently different from each, yet highly dependent on both. The quantity of water present and the timing of its presence in part determine the functions of a wetland and its role in the environment. Wetlands provide values that no other ecosystem can, including natural water quality improvement, flood protection, shoreline erosion control, opportunities for recreation and aesthetic appreciation, and natural products for human use at no cost. Wet-

lands were regarded as the "kidneys of the world". Thus, protecting wetlands in turn can protect human safety and welfare.

Wetlands are considered the most biologically diverse of all ecosystems, or the "biological supermarkets". Wetlands support species ranging from obligate aquatic to obligate terrestrial, and also provide food and/or shelter for a large and diverse range of animals and microbes. In general, wetland can be classified as four categories; i.e., marshes, swamps, bogs, and fens. In each type of wetland, the number of species, the abundance and structure of each population and community are different, which is determined at least in part by the physical and chemical features of wetland.

Although vegetation is by no means the only element of a wetland, plant life reflects the water regime and water quality faithfully, and it influences the wetland type and function. Wetland plants hold the soil in place with their roots, absorb the energy of waves, and break up the flow of stream or river currents. Trees, root mats, and other wetland vegetation also slow the speed of flood waters and distribute them more slowly over the floodplain. Plants or vegetation provide the base of the food web of wetland ecosystem, thus, recognition of the plants or vegetation in a specific wetland is usually the first step in understanding the ecosystem of the wetland as a whole.

China is one of the countries with the richest wetland resources in the world, as is shown by its 65.94 million hectares of wetland area (not including rivers and ponds) accounting for 10% of the world's total, and ranking the first in Asia and the fourth in the world in terms of area. However, the areas of China's wetlands were for a time endangered by rapid agricultural growth. Almost 30% of China's natural wetlands vanished between 1990 and 2000. Decades of cultivation reduced China's lake coverage by 1.3 million hectares. The frequent floods, droughts, red tides and sandstorms afflicting China in recent years were regarded as closely related to the shrinkage of natural wetlands, which can store excess water to control floods and purify water and soil. Waking up to the disastrous consequences, in 2000 the Chinese government implemented an action plan, called a "grain for water" program, to protect China's wetlands. Hopefully the program is not too late to mend this damaged ecosystem.

The reasons why the wetlands have long been regarded as useless, waste, or even only disease-ridden places, and listed as reserved resources for agricultural reclamation in China, may account for the absence of the basic knowledge of wetland sciences, and hence ignorance of the importance of wetlands in environmental protection. The recognition of the plant species or vegetation in detail is of first importance for the wise protection and use of wetland ecosystem. The timely publication of the book *Common Wetland Plants in China* meets such a demand.

The book was written based on the investigation data from the first national survey of wetland resources in China and the related literature. The book details 592 common wetland vascular plant species, 4 sub-species, 35 varieties, and one form, in terms of the Chinese and Latin names, main morphological character-

istics, geographical distribution, habitat and usage. These plants belong to Isotaceae, Equisetaceae, Osmundaceae, Davalliaceae, Hypolepidaceae, Parkeriaceae, Athyriaceae, Thelypteridaceae, Onocleaceae, Blechnaceae, Dryopteridaceae, Marsileaceae, Salviniaceae, Azollaceae, Taxodiaceae, Saururaceae, Chloranthaceae, Salicaceae, Betulaceae, Juglandaceae, Moraceae, Cannabaceae, Urticaceae, Santalaceae, Aristolochiaceae, Polygonaceae, Chenopodiaceae, Amaranthaceae, Sonneratiaceae, Caryophyllaceae, Nymphaeaceae, Ceratophyllaceae, Hypericaceae, Ranunculaceae, Papaveraceae, Cruciferae, Droseraceae, Saxifragaceae, Rosaceae, Leguminosae, Oxalidaceae, Zygophyllaceae, Euphorbiaceae, Callitrichaceae, Balsaminaceae, Malvaceae, Elatinaceae, Tamaricaceae, Violaceae, Lythraceae, Melastomataceae, Trapaceae, Onagraceae, Haloragidaceae, Hippuridaceae, Umbelliferae, Ericaceae, Primulaceae, Plumbaginaceae, Loganiaceae, Gentianaceae, Apocynaceae, Verbenaceae, Labiatae, Scrophulariaceae, Pedaliaceae, Lentibulariaceae, Acanthaceae, Plantaginaceae, Rubiaceae, Cucurbitaceae, Campanulaceae, Compositae, Typhaceae, Sparganiaceae, Potamogetonaceae, Ruppiaceae, Juncaginaceae, Zosteraceae, Najadaceae, Aponogetonaceae, Alismataceae, Butomaceae, Hydrocharitaceae, Gramineae, Cyperaceae, Araceae, Lemnaceae, Eriocaulaceae, Commelinaceae, Pontederiaceae, Juncaceae, Liliaceae, Amaryllidaceae, Dioscoreaceae, Taccaceae, Iridaceae, Zingiberaceae, Burmanniaceae and Orchidaceae, which reflects the diversity of wetland plants in China. The majority of these plants mentioned above have an illustration showing the morphology and some have color photographs, which are very helpful in aiding readers to easily understand the explanations.

The book can serve as a handbook for identification of the common vascular wetland plant species in China. Hopefully, the book would become a good reference for persons engaged in botany, ecology, limnology and wetland science, as well as teachers and students who major in the relevant fields of wetland science, or any other persons who are interested in this field.

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## Alpine Meadow Ecosystems in China and Impacts of Global Changes

By Zhao Xinquan. 2009. Science Press, 16, Donghuangchenggen North Street, Beijing, China, 100035. 337 pages. 88.00 CNY.

The alpine meadow refers to grassland dominated by the cold- and dry-resistant mesic geophytic and hemicryptophytic perennials, distributed mainly between the timberline and ice-snow line of the alpine zone. The alpine meadow is extensively distributed in the eastern Qinghai-Tibet Plateau and its surrounding mountainous area, being one of the most typical and unique types of vegetation in that area. The alpine meadow of Qinghai-Tibet Plateau with an area of about 700 000 km<sup>2</sup> accounts for nearly 50% of the available area of grassland in Qinghai-Tibet Plateau. In the alpine meadow, the constructive and the subordinate species are mainly the arctic-alpine components and the China-Himalayan components, adapted to conditions of high altitude and cold climate. The constructive synusia are mainly composed of the perennial rhizomatous or bunch grass species with low and short rhizomes or dense clumps, like *Kobresia*, *Carex*, and some non-clonal grass species. The alpine meadow, with its low-stature grass, simple composition, unobvious differentiation of storey, unique energy flow and material cycling, is very different from the intrazonal meadows that are extensively distributed in the low-altitude areas of China.

The process of global changes influences every ecosystem in the world, but the ecosystems in the area of high-altitude and high-latitude are definitely very sensitive to its impacts. This is especially the case for the Qinghai-Tibet Plateau, known as the "roof of the world" or the "Third Pole of the Earth", as it is a special geographical area with unique features of the climate system and ecological traits. For a long time, the Qinghai-Tibet Plateau has been an ideal natural laboratory for carrying out research in many fields of related subjects. The composition of plant species, the structure and function, as well as the dynamics of succession of the alpine meadow in Qinghai-Tibet Plateau, tend to be sensitive to the large-scale process of global changes, thus, the alpine meadow in Qinghai-Tibet Plateau could be regarded as a typical model for studying the impacts of global changes on ecosystems. Practically, such an in-depth and extensive study would be of importance for scientific and sustainable management of the alpine meadow.

In such a background, the book *Alpine Meadow Ecosystems in China and Impacts of Global Changes* was published recently. The book systematically summed up the results of the long-term field investigation, transect research, located and controlled experiments in the alpine meadow ecosystems of Qinghai-Tibet Plateau in response to global climate changes.

The main contents of the book are as follows, Chapter 1: The characteristics of the ecological environment of the alpine meadow area of Qinghai-Tibet Plateau; Chapter 2: The response and adaptation mechanism of the typical species in the alpine meadow of Qinghai-Tibet Plateau to the global climate change; Chapter 3: The relationship between the biological diversity and the functions of the alpine meadow ecosystems in Qinghai-Tibet Plateau in the background of global changes; Chapter 4: The interactions between the productivity of the alpine meadow ecosystems in Qinghai-Tibet Plateau and the processes of global change; Chapter 5: The carbon biogeochemical cycles in the alpine meadow ecosystems in Qinghai-Tibet Plateau; Chapter 6: The analysis on the stability of the alpine meadow ecosystems in Qinghai-Tibet Plateau; Chapter 7: The impacts of global changes on the safety of alpine meadow ecosystems in Qinghai-Tibet Plateau and the ecological countermeasures.

The book should become a good reference for researchers or teachers and students engaged in research on global ecology, grassland ecology and other related fields, and other persons who are interested in this field. Hopefully, the book would also become a reference for the policy makers in charge of state responses to global changes and ecological compensation, and for officers or technicians in charge of international negotiation for carbon trading or in the fields of management.

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## ENVIRONMENT

### The Link: Uncovering Our Earliest Ancestor

By Colin Tudge (with Josh Young). 2009. Little, Brown and Company (a division of Hachette Book Group, Inc.), P.O. Box 8828, Boston, Massachusetts 02114 USA. 272 pages. 28.99 CAD, Cloth.

Every scientist has a dream of making a big discovery with great impact on his or her field of research. Perhaps no better is this epitomized by a palaeon-

tologist discovering a pristine fossil with possibly grand importance on the evolution of animal life and bearing on our own evolution as human beings. In

this book, Colin Tudge describes such a finding in "Ida", a forty-seven million year old specimen and the most complete primate fossil ever found. He aims to convey the excitement of this most unusual fossil discovery and describe the importance of the specimen to our understanding of primate evolution. Unearthed by a private fossil collector, the specimen (given the scientific name *Darwinius masillae*) was unveiled to Norwegian palaeontologist Jørn Hurum and later sold under much secrecy to Oslo's Natural History Museum, where it is currently on display.

The book starts off in prose style, as Tudge tells a story of what might have happened as Ida perished a long time ago in Eocene times, drowning in a lake with unusually fine conditions for specimen preservation. The site is now known as the Messel Pit, a superb location for fossil hunters just 35 km southeast of Frankfurt, Germany. Once the prosaic tale of Ida is told, the book transforms into a more common form of popular science writing, including detailed descriptions of the specimen itself. However, there is only so much you can tell about a fossil specimen. Tudge expands his book by rather nicely weaving in other aspects of interest, including palaeontology, climate history, the rise of mammals, primate evolution, and ultimately our own evolution as humans. The result is a rather nice glimpse into how evolutionary science,

through the addition of a myriad of small puzzle pieces, aims at an overall understanding of the evolution of life on this planet. However, the book feels repetitive at times, and too much emphasis is spent on how fantastic this particular fossil find is. No doubt Ida is a valuable specimen, but as the book was released immediately following the scientific publication describing the find (Franzen et al. 2009), it is simply too early to tell just how valuable; scientific progress is made only via the continuous critical evaluation of new evidence against old, not through self-proclaimed excellence. Critical readers with a background in science will therefore dislike the salesmanship flavour of the *The Link*. Indeed, Jørn Hurum decided to orchestrate the launch of the fossil in a combined scientific and public event. On the other hand, readers with a non-professional interest in science and in palaeontology in general may enjoy the book as a fascinating story, especially as it touches upon our own history.

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### High-Arctic Ecosystem Dynamics in a Changing Climate: Ten Years of Monitoring and Research at Zackenberg Research Station, Northeast Greenland. Advances in Ecological Research (Volume 40)

Edited by H. Meltofte, T.R. Christensen, B. Elberling, M. C. Forchhammer and M. Rasch. 2008. Academic Press, Elsevier, 3251 Riverport Lane. Maryland Heights, Missouri 63043. USA. 596 pages. 105 USD.

This book is packed with information and analyzed data. It may even serve as a "textbook on structure and functioning of a high-arctic ecosystem under climate change". Its 63 contributors keep the promise: great results and findings from diverse disciplines covering 10 years of research in Greenland get delivered to the global audience. The Zackenberg Research Station is one of the few localities where high-detail Arctic research is carried out (together with Abisko, Sweden; Svalbard, Norway; Toolik and Barrow, Alaska; relevant research stations in Canada, Iceland, and Russia either do not really exist or not well published, synthesized and promoted). And so this book is among the first to report long-term findings in one synthesis volume. Ecological research studies where "more than 1500 physical and biological parameters have been measured annually" and covering an entire decade are generally difficult to come by (only to be compared with other famous research stations such as La Selva in Costa Rica (for instance)). Due to the huge climate change discussion, this book provides a great overview and many new facts and viewpoints. In addition, it provides a benchmark to show us where the western

countries are standing regarding Arctic science and their effectiveness in monitoring and managing the Arctic which is to be science-based and for sustainability.

During the 10 years of this research, the Arctic warmed already by 2.25 degrees Celsius. With Arctic warming expected to increase up to 8 degrees Celsius, I recommend this book on many accounts: it fits a niche, is very well edited, covers ecosystem components and is a "must have" for people interested in the Arctic, climate change, Greenland, and western science. The introductory and final synthesis chapters alone are great highlights; for instance "the arthropod data set used in this study is probably the most extensive from the entire Arctic"! Another real strength is the use and interpretation of IPCC [Intergovernmental Panel on Climate Change] and (downscaled) climate models. It's made clear in the book text of 563 pages that large-scale temperature events such as NAO [North Atlantic Oscillations] can explain biological effects (e.g., predation and populations) but they are an inherent part of global climate change, and are thus part of the man-made component.



Most of the 21 chapters and the 13 themes deal with the issues of change in snow melt, snow depth, a longer growing season, the 14-day advance spring season, higher (air) temperature and general variabilities. The notions of ice free lakes, UV radiation and secondary plant metabolites, below-the-ground impacts, and archeology are other great topics to read up on. Links with the marine environment (e.g., sea ice) get elaborated on in detail, and so are many other science topics such as pollination, muskoxen, lemmings, migratory shorebirds (not included are gyrfalcons and most songbirds, though), tadpole shrimp, fish, (introduced) beetles, shrubs, ground-living plants, phenology, glaciers, permafrost, methane release and "weather". The infrared NDVI [Normalized Difference Vegetation Index] remote sensing work and the circumpolar breeding performance of arctic waders I also read with great interest. The chapter summaries provided make an informative text by themselves, highlighting relevant details in each chapter for managers and the lay public that are inclined to skip methodological details, for instance. But I think all audiences will find it rather annoying that the literature references follow a format that actually omits (!) the publication titles.

The book elaborates on forecasting climate change each of its research topics. But many authors retreat to the argument of "uncertainty" and make conservative understatement for the sake of a wrongly perceived "scientific objectivity", or just use qualitative expert extrapolations, instead of employing science-based quantitative modeling, meta-analysis, the development of new methods (if needed) and the plain use of "common sense".

They should invoke these because (i) the man-made contamination of the atmosphere will certainly not be beneficial, and (ii) the warming trend will result in extinction of local DNA specifically adapted to the Arctic (both are points not made by the Arctic science experts here). Also, it would have been helpful if the editors had insisted on the use of a global taxonomy (e.g., ITIS) so that species and effects can be better described and compared globally.

A detailed index of 12 pages is found at the end of the book. Each book chapter has a nice section of tables and figures (mostly in high-quality color; unfortunately, I could not find a digital version of these to be used for lectures).

This milestone publication is a celebration of the traditional scientific approach, trying to understand biological mechanisms (a la "we sort'em post mortem") a concept that has proved inefficient worldwide

and which did not really halt climate change and loss of species and wilderness. There are a few points where I strongly disagree with the authors. First, this publication has actually more American researchers involved than Greenlanders. Such a lack of native views must represent another rather outdated science concept and expert view that is driven by an "Old Boys" network, mostly being Danish with some Swedish, U.S. and Belgium help (e.g., no Canadian, Icelandic, Norwegian, Finish or Russian co-authors can be seen). Second, this book is basically a (Danish) governmental research exercise (mostly National Environmental Research Institute and University of Copenhagen) that presents us with a selective, and somewhat one-sided, view of "Arctic science". Next, the statistics employed in this book are virtually all linear, additive, correlational (e.g., the misleading notion of "coupling"), and non-spatial (tested hypotheses are often not mentioned or "poor"), whereas it has been known for over 30 years that detectability issues matter and that ecology, climate and the Arctic are complex, non-linear, multivariate, inherently spatial, and require a diversity of approaches to provide us with true progress. Lastly, it comes as a big surprise that this book makes no relevant reference to the International Polar Year (IPY; a major and ongoing planning and global science initiative for many years, and happening when this book was published. Whereas other recent Arctic programs and initiatives such as AMAP [Arctic Monitoring and Assessment Programme], ACIA [Arctic Climate Impact Assessment], ITEX [International Tundra Experiment Program] and ICARPII [International Conference on Arctic Research Planning II] are mentioned). The reader assumes that the great Zackenberg data in the BioBasis database are getting submitted to IPY and will be freely available to the global audience in compatible formats and with high-quality metadata.

This very informative science book should indeed be on your book shelf, and read by many people worldwide. However, if we really want to keep a viable Arctic, we need a better and all inclusive global economy with less growth and resource consumption, compatible and readily available global data sharing, and still have to investigate truly sustainable ways of management and living (none of this has been mentioned, studied or demanded in this book).

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## Earth Matters

Edited by Elinor Greenwood and Elizabeth Haldane. 2008. DK Publishing, 375 Hudson Street, New York, New York 10014 USA. 256 pages, 27.99 USD.

Subtitled "an encyclopedia of ecology", *Earth Matters* presents a colourful survey of the world's major

biomes and biodiversity, aimed at younger readers. As with all Dorling Kindersley books, this one's main

strength is its colourful and eye-catching design, with interesting graphics and splendid images. It is very similar in style and appearance to other well-received children's books by this publisher. Packed with information and rich in content, it succeeds admirably in attracting and holding the reader's attention.

The book is divided into three parts. The first part begins with an introduction to the story of life on earth. It briefly reviews some important geobiological aspects of ecosystems, including the carbon and water cycles, and presents a two-page map with the eight biomes that are the focus of the main part of the book. These comprise the polar regions, temperate forests, deserts, grasslands, tropical forests, mountains, freshwater, and oceans. Each biome chapter has a similar format, starting with a two-page spread featuring a world map, showing the distribution of the biome and naming some of the main geographic areas associated with it. The biomes are treated at a high level of abstraction, although some major ecosystems within them are highlighted. Thus, the temperate forests chapter includes two pages on the boreal ecosystem and the deciduous ecosystem, the tropical forests chapter spotlights cloud forests and tropical dry forest, and the freshwater chapter features the Everglades. Each biome is also characterized by one or more "feature creatures", predominantly mammals, but also including some birds, amphibians, insects, and plants. In the chapter on deserts, for example, we learn about the Bactrian camel and the saguaro cactus, whereas the polar bear, the caribou and the Emperor penguin exemplify the polar areas. In all cases the creatures are endangered or otherwise vulnerable to human activities. The most extreme case is that of the golden toad (*Incilius periglenes*) of Costa Rica, featured in the tropical forest chapter, which was only described in 1966 and is now thought to be extinct. At the end of each biome chapter is a section on "Making a difference", which suggests some ways in which individuals can help protect the particular ecosystems under scrutiny. The concluding part of the book is called "Helping the Earth". Here, the messages of personal action and responsibility are re-iterated. The focus is on renewable energy and wise use of energy resources. Throughout, the volume has a strong eco-activist tone and is clearly designed to encourage a sense of environmental stewardship and concern for the Earth in young readers.

Information is not offered as a narrative, but is arranged as a series of snippets or factoids, with striking use of images and distinctive typography. The "Making a Difference" sections, for instance, are laid out like a cork notice board, with notes and photos apparently "pinned" in place. Every page has a well-balanced mix of text and graphics. The photos are usually high quality, and are in focus, clear, well cropped, and with good colour rendition. Images are sometimes composite. For example, the savanna ecosystem animals (page 125) are image cutouts, presum-

ably reprocessed to the same relative scale, and then superimposed on a background. Occasionally this leads to some oddities, such as an apparently five-legged deer (p. 178). The consistent style and layout include some common icon elements, such as stylized adult and child silhouettes that provide relative sizes for animals and plants. A stylized footprint in a "sticker" headed "what you can do" is used to highlight eco-friendly actions, such as building a birdhouse (page 89) or carrying a reusable water bottle (page 207).

The designers have cleverly used a variety of approaches to displaying data. Illustrations include some simple graphs and charts, such as a comparison of monthly rainfall amounts between Manaus, Brazil, and Paris, France (page 142), or the average monthly temperature on Mount Washington, USA (page 166). Elsewhere, illustrations include block diagrams (e.g., showing the river system, page 188), pie charts (e.g., showing how harvested wood is used, page 83, or sources of energy, pages 30-31), and cycle diagrams (e.g., showing the various paths for solar energy, page 47, or the carbon cycle, pages 26-27). Variable-sized graphics are used very effectively to present numerical data in an easily understandable format. Different sized water drops (page 32) show the relative abundance of the world's freshwater in different storage systems (glaciers and ice caps, groundwater, and surface water), whereas individuals' carbon footprints in various countries are dramatically illustrated by different-sized footprints (pages 36-37). The strong geographic focus is reflected in an abundant and effective use of maps and other remote-sensing imagery, especially the use of repeat imagery. The reduction in the extent of the Aral Sea is clearly shown in a comparison of satellite images from 1989 and 2003 (page 197), while a map series shows the reduction in the area of Lake Chad between 1963 and 2001 (page 109), and the shrinking "Altsch" [*sic* – should be Aletsch] Glacier of Switzerland is documented by photos taken in 1979 and 2002 (page 181).

Due to the sophisticated integration of different levels of information and presentation methods, *Earth Matters* will likely appeal to a broad age-range. Younger children will enjoy flipping through it and looking at the colourful pictures, while the text provides the more contextual background for older readers. The book is robust and well made, with a thick cover and mid-weight paper that should withstand much reading. I feel that it would probably appeal to the eight-to-twelve-year-old age range. One of my colleagues in the youth education field thought that the content was diverse and rich enough to interest a somewhat broader age range, perhaps seven to fourteen years old.

The book does have some weaknesses. Animals and plants are identified only by their common names, losing the opportunity to introduce Linnean terminology, a basic bioscience concept and one many youngsters, such as those enthusiastic about dinosaurs, will



have some familiarity with already. This choice leads to some confusion and mistakes. We are told that in the Canadian Arctic Inuit people have recently seen robins, birds that have not previously been found there (page 29). However, the snippet is illustrated by a photo of the European robin (*Erithacus rubecula*) not, as it should be, by the North American robin (*Turdus migratorius*), a species in a different family. The same common name can often be used for very different creatures in different parts of the world. The buffalo raised by the Marsh Arabs of Iraq (page 200) is not the same as the buffalo (actually a bison) illustrating the geological Age of Mammals (page 19).

Although the survey of biomes is a useful organizational approach, as it summarizes lots of information in a short form, it does lump together creatures from very different areas of the world. Often, the home regions or geographic distribution of the creatures shown are not identified, and this may confuse some readers. For example, the deciduous forest ecosystem is illustrated by a characteristic British woodland (page 77-78), complete with bluebells (*Endymion non-scriptum*), badgers (*Meles meles*), and tawny owls (*Strix aluco*). However, the page also includes a picture of a chipmunk (*Tamias* sp.), a non-European species that would not be found in such woodland. The lowland rainforest ecosystem is illustrated by an image (page 142-143) that includes a toucan and caiman, which have predominantly South American distributions, in the same spread as a gibbon, species of which are found in Southeast Asia. This juxtaposition implies that these creatures could be found living in the same place, a misleading impression. In some cases, the geographic context for images is missing, especially for those images showing human activities. Where do people fish for eels with reed traps (page 201) or live in houses made of reeds? Where do people harvest cockles (page 214) or still dive for pearls?

There is also some confusion about the geographic locale of the target audience. The book appears to be aimed at readers in both the U.S. and the U.K., because sometimes terms are US-specific and sometimes UK-specific. For example, on page 136 readers are encouraged to write to their Congressperson, something only U.S. readers can do, although the animal chosen to illustrate the sample letter protesting a local development project is a European hedgehog. On the same page, readers are exhorted to leave a patch of long grass in their garden for wildlife and assured that if they do, hedgehogs might appear, something that would not happen in the U.S. The geographic muddle carries over into other parts of the text. Scandinavian people refer to their herd animals as reindeer, not caribou (page 175), and Arctic people drive dog sleds not sleighs (page 44). There needs to be more clarity and consistency in the geographic identity of the voice used throughout the book.

*Earth Matters* pulls together information on a great diversity of topics. I am somewhat ambivalent about its factoid approach and the consequent oversimplification of complex issues, especially when currently trendy eco-actions are involved. The directive to eat locally grown food (page 137) ignores the cultural reality that Western consumers demand a wide range of food resources at all seasons of the year. This demand can result in substantial energy inputs expended to grow crops, such as greenhouse-grown salad vegetables, beyond their natural range. In this case, simply "eating locally" is not necessarily the most environmentally friendly action. A more informed recommendation would be to "eat seasonally", consuming only organic crops that can be locally grown without the investment of additional energy or irrigation. However, it is unlikely that consumers in most regions would be satisfied with the restricted and seasonally variable diet that would result. The subtleties of such issues are obviously not identified here but could perhaps form the basis for classroom discussion or parent-guided conversations. I saw many places where statements could act as starting points for more thoughtful investigation.

Inevitably, in such a broad-based survey, there are errors. Mammoths and modern humans co-existed for thousands of years in Eurasia, where mammoths were not "wiped out" in their first encounter with hunters, as implied on page 20. Wolves were exterminated only in the U.S. portion of the Rocky Mountains (page 178); they maintained populations in the Canadian Rockies. Tumbleweed, or Russian thistle (*Salsola* spp.), was introduced to the North American prairies and spread through the interior Great Plains, not the west coast (page 121). The Lauterbrunnen valley is a superb example of a classic glacier-cut U-shaped valley, not an example of a valley produced by river erosion (page 178). Such mistakes are irritating but do not detract significantly from the book's usefulness.

However, *Earth Matters* opens with a statement of such monumental hyperbole and silliness that I almost read no further. In the foreword, David de Rothschild, identified as an adventurer and ecologist, states that inside the book "you will find everything you will ever want to know about Earth's ecology". If the intent is to present accurate and interesting information, why begin with a statement so patently untrue that it undermines the credibility of what follows? Fortunately, I read on and found the rest of the book rather more measured than that inflated and misleading declaration led me to believe. The book is well intentioned and certainly is attractive and easy to read. Despite some flaws, it has considerable educational and informational value. Overall, I liked it and I imagine that most children will enjoy it too.

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## MISCELLANEOUS

**A Sound Like Water Dripping**

By Søren Bondrup-Nielsen. 2009. Gaspereau Press, 47 Church Avenue, Kentville, Nova Scotia B4N 2M7 Canada. 236 pages, illus. 26.95 CAD, Paper.

*A Sound Like Water Dripping*, by Acadia University biologist Søren Bondrup-Nielsen, is an engaging account of the author's graduate research on the boreal owl in Canada in the 1970s, when very little was known about the species. Bondrup-Nielsen went on to discover and study the first boreal owl nest in Ontario.

The book's intriguing title is based on a description of the owl's song in a Montagnais legend – the only reference to boreal owl vocalisations the author could find at the time. Armed with that description, a smattering of background information, a recording of the closely related European Tengmalm's Owl song, plus the necessary equipment and enthusiasm for conducting research in the north in winter, the young Bondrup-Nielsen stepped onto the train bound for northern Ontario.

The text of the book is based on the author's meticulous and detailed field notes, which he revisited to write the book. "I closed off from the world around me," he writes, "and withdrew into my mind to relive the past through matured reflection." The result is an intimate, honest, delightful, and often humorous account of a biology graduate student's struggles and successes, disappointments and thrills, follies and triumphs, all told in fine-grained detail accompanied by charming photographs.

Some of the more memorable passages revolve around incidents in the north or discoveries related to research. One of the author's tasks, for example, was to trap and dissect samples of the small rodents eaten by boreal owls. He writes about the stories he is able to read from the necropsies of females through close attention to the uterus – particularly its size, form, scars, follicles containing eggs, and embryos. He adds that he was always saddened to discover females that had been

lactating, because it meant a nest of orphaned young.

More humorous is his story of bumping into a moose one overcast night as he returned home from monitoring owl nests. He writes of walking along lost in contemplation of the warm bed awaiting him back in his cabin, when he suddenly hit "a large, warm, furry wall." The wall, which turned out to be a moose, took off immediately and crashed away through the bush, leaving Bondrup-Nielsen standing alone, baffled, and wondering who had been more shocked by the encounter. He was also puzzled at how he managed to sneak up on a moose undetected.

One of the more salient research discovery stories did not unfold in the field, but rather inadvertently in the walk-in bird cage on the roof of the University of Toronto Zoology building, where the author kept a captive boreal owl named Ruffles. On a weekend when he planned to be away, Bondrup-Nielsen asked a fellow graduate student to feed the owl its usual daily thawed white laboratory mouse. One day the student forgot to thaw the mouse and gave Ruffles a frozen one instead. The owl's subsequent behaviour, as reported by the student who went to check on the bird later, was curious; Ruffles was sitting on the mouse. Bondrup-Nielsen put two and two together and concluded that the owl was thawing its prey, a fact he later confirmed through experiments.

Bondrup-Nielsen is a natural storyteller, and he manages to avoid heavy jargon, which makes *A Sound Like Water Dripping* particularly easy to read. This well-written, engaging, and beautifully illustrated book would make a wonderful addition to the library of any naturalist or birder interested in a good story.

RENATE SANDER-REGIER

3, 11th Line, Bristol, Quebec J0X 1G0 Canada

**The Beachcomber's Guide to Seashore Life in the Pacific Northwest – Revised edition**

By J. Duane Sept. 2009. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada 224 pages., 26.95 CAD Paper.

As a frequent comber of the beaches of the Pacific Northwest coast, I was delighted to own this guide. It covers the area of British Columbia, Washington, and Oregon.

It begins with a brief explanation of tides and the various intertidal habitats, with a warning of dangers that accompany searching in these areas. The bulk of the book covers a description and excellent photos of some 270 commonly found specimens. These are arranged according to phylum currently in use; genus and species are given in Latin as well as the common

name. There is a description of each species, along with the size, habitat and range. Also included, are other pertinent facts of natural history interest.

I found this guide very informative, clearly written and beautifully illustrated. It certainly will be a stimulus for any reader to further interest in seashore life, both animal and plant.

ELIZABETH PARMIS

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Canada



## Weather's Greatest Mysteries Solved!

By Randy Cerveny. 2009. Prometheus Books, 59 John Glenn Drive, Amherst, New York 14228-2197 USA. 328 pages. 26.98 USD, Cloth.

This book's catchy title attracted me to review it, but the title misrepresented the content. The book was written for the curious, and specialists will find it useful for a few references. It was easy to read, and most readers will find in it something new.

Most issues discussed related to "climate", not "weather", though half a chapter was devoted to distinctions between these terms. Several events discussed do not qualify as "greatest" by any objective criteria. Some issues discussed were not "solved" (yet). Others that seemed mysteries, before they were studied, had been partly explained for decades. The author admitted that some "solutions" may be changed as more information becomes available — hardly "mysteries solved". The title seemed created as a sales gimmick, that the author accepted — to get the book published, and sold?

Major (prehistoric) events such as the asteroid collision at the Cretaceous/Tertiary transition disrupted weather and climate patterns around the Earth, far beyond those of the impact. That event and its aftermath were treated more fully, for similar readership, in *The Eternal Frontier* (T. Flannery, 1999 — not cited by Cerveny).

- The "bottleneck" in human evolution 73 000 years ago (newly proposed in the 1990s), from a prolonged "winter" caused by loss of solar energy input, following eruption of supervolcano Toba, similar but much larger than those of Tamboro in 1816, and Drakatoa in 1883.

- A disastrous famine and disease (documented by Romans, but unexplained) that ravaged the Mediterranean around 536 A.D. also correlated with sun obscured by dust, from a volcanic eruption or a comet collision, but which?

- Collapses of civilizations after climatic changes, of less than world scale, in the Indus Valley and among the early Greeks (separate chapters), were discussed in *Climates of Hunger* R. Bryson and T. Murray 1977 — cited by Cerveny).

- The "Mayan mega-drought" that, with a disease outbreak (result of drought?), ended a civilization in Meso-America before 1000 A.D., is still a "great mystery"; Cerveny admitted its cause was not yet "solved".

Several events discussed had mainly local significance.

- The Israelites passage of the Red Sea would be dismissed as minor if published in a non-Christian country.

- The collapse of Petra's civilization was caused by a tectonic event, such as might hit Los Angeles or Wellington, New Zealand, any year — without affecting most of the earth.

- Columbus, not meeting a hurricane, survived to report new land, but someone else would have reported America soon in that age of exploration.

- the effect of Tibet's "weather spies" (in empire-building in central Asia) hardly qualifies as a "great mystery".

Other chapters discussed long-known phenomena in discussing weather/climate variation in various areas.

- The Little Ice Age, named in 20<sup>th</sup> Century, began long before 1500 in the Arctic. The decline of Norse Greenland settlements, from increasing cold in a marginal area (Bryson and Murray 1977), began before 1300 and was done by 1500. Grape-growing (and wine-making) in medieval England ended by 1500 (same authors).

- The El Nino Southern Oscillation (ENSO) was used to explain climate outside the Pacific after 1980, but El Nino — affecting bird populations of South America — was described much earlier (e.g., *Oceanic Birds of South America*, Murphy 1936).

- The Gulf Stream was known to sailors, and its effects on climate of western Europe to landsmen, 300 years ago. The similar current in the north Pacific was outlined a century ago. People then "in the know" had narrower interests, so the "thermohaline circulation" emerged as oceanography and climatology cast wider nets. Those phenomena were allowed for long before any explanation was sought.

This book's idea — that climate/weather helps explain some major events that affected many people — is valid. In support, the author assembled information, some little known previously, for the lay public. In my view, he included too many examples that weren't "great mysteries", and others that haven't yet been solved — thus "putting the lie" to the book's title. But it still may be read with enjoyment and for information.

A. J. (TONY) ERSKINE

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Canada

## NEW TITLES

Prepared by Roy John

† Available for review \* Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

## ZOOLOGY

\* **The Rise of Amphibians – 365 Million Years of Evolution.** By Robert Carroll. 2009. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland. 544 pages, 78.50 CAD.

\* **Birds of Europe, Russia, China and Japan: Non-Passerines. Loons to Woodpeckers.** By Norman Arlott. 2009. Princeton University Press: 41 William Street, Princeton, New Jersey, USA, 08540-5237. 240 pages. 29.95 USD, Paper.

\* **The Migration of Birds: Seasons on the Wing.** By Janice M. Hughes. 2009. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 207 pages, 40 CAD, Cloth.

**Guide to the Freshwater Invertebrates of the Midwest** [Publication 11]. By the Kansas Biological Survey. University Press of Kansas, 2502 Westbrooke Circle, Lawrence KS 66045-4444. 230 pages. 51.00 USD including shipping, Cloth.

**Following the Water: a Hydromancer's Notebook.** By David M. Carroll. 2009. Houghton Mifflin Harcourt, 215 Park Avenue, South, New York, New York 10003. 208 pages, 24.00 USD.

\* **Mammals of the World – Carnivora.** Edited by Don E. Wilson and Russell A. Mittermeier. 2009. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 728 pages, 230 USD.

\* **The North American Porcupine.** By Uldis Roze. 2009. Cornell University Press, Sage House 512 East State Street, Ithaca, New York 14850. 282 pages, 35 USD Cloth.

**A Field Guide to Seashells and Shellfish in the Pacific Northwest.** By R. M. Harbo. 2009. Harbour Publishing, PO Box 219, Madeira Park, British Columbia V0N 2H0. 7.95 CAD Laminated pamphlet.

**The Beachcomber's Guide to Seashore Life in the Pacific Northwest. Revised Edition.** By J.D. Sept. 2009. Harbour Publishing, PO Box 219, Madeira Park, British Columbia V0N 2H0. 224 pages, 26.95 CAD.

\* **Snakes: Ecology and Conservation.** Edited by Stephen J. Mullin and Richard A. Seigel. 2009. Cornell University Press, 750 Cascadilla Street, Ithaca, New York. 392 pages. 60.00 USD, Cloth.

\* **Turtles of the United States and Canada; Second Edition.** By Carl H. Ernst and Jeffrey E. Lovich. 2009. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland. 827 pages, USD, Cloth.

## BOTANY

**Forestry and Biodiversity.** Edited by F. Bunnell and G. Dunsworth. 2009. University of British Columbia, 6344 Memorial Road, Vancouver British Columbia V6T 1Z2. 374 pages, 85 CAD.

**The Bizarre and Incredible World of Plants.** By Wolfgang Stuppy, Rob Kessler and Madeline Harley. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 144 pages, 29.95 CAD.

## OTHER

\* **Amur-Heilong River Basin Reader.** By Eugene A. Simonov and Thomas D. Dahmer. 2008. Ecosystems Limited, 2/F, Kingsun Computer Building, 40 Shek Pai Wan Road, Aberdeen, Hong Kong. 448 pages. 72 USD, Paper.

\* **The Link: Uncovering Our Earliest Ancestors** by Colin Tudge and Josh Young. 2009. Little, Brown and Company, Hachette Book Group. 237 Park Avenue, New York, New York 10017. 262 pages. 18. GBP.

**World Ocean Census – A Global Survey of Marine Life.** By Darlene Trew Crist, Gail Scowcroft, James M. Harding, Jr. 2009. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 256 pages, 40.00 CAD.

**Planet Ape.** By Desmond Morris with Steve Parker. 2009. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 288 pages, 49.95 CAD, Cloth.

**Sensing Changes – Technologies, Environments, and the Everyday, 1953 – 2003.** Bu Joy Parr. 2009. University of British Columbia, 6344 Memorial Road, Vancouver, British Columbia V6T 1Z2. 222 pages. 85 CAD, Cloth.

**Setting the Standard – Certification, Governance, and the Forest Stewardship Council.** By Chris Tollefson, Fred Gale and David Hale. 2008. University of British Columbia, 6344 Memorial Road, Vancouver British Columbia V6T 1Z2. 424 pages, 85.00 CAD, Cloth.

**The Industrial Transformation of Subarctic Canada.** By Elizabeth Piper. 2009. University of British Columbia, 6344 Memorial Road, Vancouver British Columbia V6T 1Z2. 424 pages. 85.00 CAD, Cloth.

**Surviving – How Animals Adapt to Their Environments.** By Alessandro Minelli and Maria Pia Mannucci. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 200 pages. 45.00 CAD Cloth.



## CHILDREN

**Maritime Monsters – A Field Guide.** By S. Vernon. 2009. Nimbus Publishing Ltd., P.O. Box 9166, Halifax, Nova Scotia B3K 5M8. 32 pages. 12.95 CAD Paper.

**Editor's note:** We were informed 68 books on insects of China. Most are in Chinese and some of them are new. The selection below are mostly recent books and have at least some English or Latin and are of potential use to a Canadian. Further information can be obtained from <http://www.hceis.com>.

— **A Photographic Guide to Butterflies of China** [Latin Name Index]. By Huang Hao Zhang. 19.00 USD.

— **Identification Manual for Butterflies in China** [English and Latin Names Index]. By Wu Chunsheng. 39.00 USD.

— **Systematic Butterfly Names of the World** [English summary, Latin names index] By Shou Jianxin, Chou Io and Li Yufei. 65.00 USD.

— **Butterflies Fauna Sinica: Lycaenidae** [Chinese and English]. No author and ten years old. 110.00 USD.

— **Classification and Identification of Chinese Butterflies** [English summary]. By Chou Io. 11 years old. 88.00 USD.

— **Flowers that can fly – Butterflies of Yunnan, China** [Chinese and English]. By Liu Jiazhu. Ten years old. 15.00 USD.

— **Oecophoridae of China** [English] By Wang Shuxia. 90.00 USD.

— **Fauna of Pyralidae of Wuyishan Nature Reserve in China** [Latin names and English Introduction] By Wang Jiashe and Song Shimei. 35.00 USD.

— **Lushan Annals of Moths and Butterflies** [English Abstract] By Fang Yuqing. 35.00 USD.

# News and Comment

## ***Marine Turtle Newsletter* (123) January 2009**

ARTICLES: Editorial: Creating community collaborations (Mark Hamann) — Mixed stocks of Green Turtles (*Chelonia mydas*) foraging on Clack Reef, Northern Great Barrier Reef, identified from long term tagging studies (Colin J. Limpus, Ian Bell, and Jeffery D. Miller) — Feeding ecology of Green Turtles (*Chelonia mydas*) from Shoalwater Bay, Australia (Karen E. Arthur, Kathryn M. McMahon, Colin J. Limpus, and William C. Dennison) — Does Fiji's turtle moratorium work? (Merewalesi Laveti and Kenneth T. MacKay) — Marine turtle hunting in the Ha'apai Group, Tonga (Sulieti Havea and Kenneth T. MacKay) — Foraging turtles around Tetepare Island, Solomon Islands (David Argument, Kenneth T. MacKay and Barry H. Krueger) — Comments to Mrosovsky's suggestions for Orissa — LETTERS TO THE EDI-

TORS — IUCN-MTSG QUARTERLY UPDATE — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

*The Marine Turtle Newsletter* is edited by Lisa M. Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA; and Matthew H. Godfrey, NC Sea Turtle Project, North Carolina Wildlife Resources Commission, 1507 Ann Street, Beaufort, North Carolina 28516 USA. Subscriptions and donations towards the production of the MTN can be made online at <<http://www.seaturtle.org/mtn/>> or postal mail to Michael S. Coyne (Managing Editor) Marine Turtle Newsletter, A321 LSRC, Box 90328 Nicholas School of Environment and Earth Sciences, Duke University, Durham, North Carolina 27708-0328 USA; e-mail: [mcoyne@seaturtle.org](mailto:mcoyne@seaturtle.org).

## **William J. (Bill) Cody 1922-2009**

Bill Cody died in Ottawa 23 March 2009 nearly four months after his eighty-sixth birthday. Bill's impact on natural history publication in Canada was long felt through his tenure as Business Manager of *The Canadian Field-Naturalist* for nearly 60 years. Concurrently, he was a productive botanist for the Canada Department of Agriculture, Ottawa, for 41 years from October 1946

to retirement in December 1987, and continuing as an emeritus there in postretirement for another 20 active years. Bills major recent work was the *Flora of the Yukon Territory* (1966, revised second edition 2000). A full tribute with bibliography will appear in a later issue of *The Canadian Field-Naturalist*.



## The Canadian Field-Naturalist Online

A list of contents for each issue of *The Canadian Field-Naturalist* beginning with 110(4) October-December 1996 is available on The Ottawa Field-Naturalists' Club website:

**<http://www.ofnc.ca/index.html>**

For recent issues Abstracts of articles and notes, and full content of the News and Comment and Book Review sections are available to all viewers. PDFs or reprints of full text of articles and notes should be requested directly from corresponding authors for each paper.

## Advice for Contributors to *The Canadian Field-Naturalist*

### Content

*The Canadian Field-Naturalist* is a medium for the publication of scientific papers by amateur and professional naturalists or field biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

### Manuscripts

Please submit by e-mail **to the Editor**, in either English or French, one complete manuscript **written in the journal style**. Manuscripts may also be submitted (one copy) by post. If sending by post include a disc of the complete text and illustrations. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Manuscripts should be formatted for standard-size paper, **doublespaced throughout**, generous margins to allow for copy marking, and **each page numbered**. For Articles and Notes provide a citation strip, an abstract, and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Be certain to check that all text citations are included either in the *Documents Cited* (for unpublished reports, manuscripts and web pages) indicated in text with an \* after date or *Literature Cited* for published/printed and widely circulated books and papers.)

Check recent issues (particularly Literature Cited) for journal format. Either "Canadian" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

### Illustrations

Electronic versions of photographs should be high resolution. Photographic reproduction of line drawings should be **no larger than a standard page**.

### Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the journal.

### Special Charges — Please take note

Authors **must share in the cost of publication** by paying \$90 for each page, plus \$20 for each illustration (any size up to a full page), and up to \$90 per page for tables (depending on size). Authors may also be charged for their changes in proofs. Reproduction of color photos is extremely expensive; price quotations may be obtained from the Editor.

Limited journal funds are available to help offset publication charges to authors without grants or institutional support. Requests for financial assistance should be made to the Editor when the manuscript is submitted and noted when the galley is returned.

### Reprints

An order form for the purchase of reprints or pdf will accompany the galley proofs sent to the authors. Invoices for publication costs will be sent when the submission is published.

FRANCIS R. COOK, Editor  
RR 3 North Augusta, Ontario K0G 1R0 Canada



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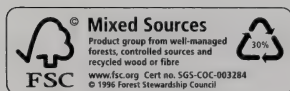
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# The CANADIAN FIELD-NATURALIST

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Volume 123, Number 2

April-June 2009

# The Ottawa Field-Naturalists' Club

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Governor General of Canada

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## The Canadian Field-Naturalist

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**COVER:** The health of this ash-rich moist forest at Point Pelee National Park, Ontario is currently being negatively affected by the invasive Emerald Ash Borer. Photograph taken in 1986; provided by Dr. Sanjay Tewari, Restoration Ecologist, Point Pelee National Park of Canada. See breeding bird survey by Dodds and Otis, pages 99-106.



## The Canadian Field-Naturalist

Volume 123, Number 2

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Breeding Birds of Mature Woodlands of Point Pelee National Park  
Prior to Infestation by Emerald Ash Borer, *Agrilus planipennis*HOLLY D. DODDS<sup>1</sup> and GARD W. OTIS

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The Emerald Ash Borer (EAB) is a wood-boring beetle native to Asia that now infests and kills ash trees (*Fraxinus* spp.) in North America. Many ecological communities will be dramatically altered by the mortality of ash trees caused by this invasive insect. The EAB recently colonized Point Pelee National Park of Canada in extreme southwestern Ontario, Canada, a site famous for its unusual plant and animal diversity as well as its extraordinary bird migrations. We conducted a census of breeding birds in two ash-rich mature forests at Point Pelee in order to obtain baseline data on the breeding bird communities prior to changes in forest communities that are likely to be caused by the EAB. Here we report the results of the bird census and review possible changes to the breeding bird fauna of Point Pelee that may result from ash tree mortality and the associated disruption of forest communities.

**Key Words:** Bird fauna, Point Pelee National Park of Canada, Emerald Ash Borer, *Agrilus planipennis*, *Fraxinus* spp., ash trees, invasive beetles, Blue Ash, *Fraxinus quadrangulata*.

Point Pelee, the southernmost region of mainland Canada, is an elongated peninsula that juts into Lake Erie. Point Pelee National Park of Canada (PPNP) is composed of marshes, forests, beaches and fields bordered to the north by a highly fragmented agricultural landscape (Smits et al. 2005). The combination of its southerly location and the moderating influence of the lake provides Point Pelee with the warmest mean temperatures, mildest winters, and longest frost-free period in Ontario (McLachlan and Bazely 2001). As a result, the flora and fauna of the park are more similar to those of the American Midwest and the Carolinas than to the rest of Canada. Because of its unique biological characteristics within Canada, PPNP was the first Canadian park established for its biological significance (Crow and Smith 2007).

Carolinian forests constitute an uncommon and fragmented Canadian habitat restricted primarily to sites near the northern shore of Lake Erie (National Parks Service 1972\*). They are home to many species characteristic of the Carolinian life zone (National Parks Service 1972\*) which covers just 0.25% of Canada's landmass yet contains the highest biological diversity and largest number of rare plant and animal species in the country (McLachlan and Bazely 2002). The forests of Point Pelee are unique within Canada, even compared to other Carolinian forests. They are

dominated by three species: Northern Hackberry (*Celtis occidentalis*), Black Walnut (*Juglans nigra*), and Red/Green Ash (*Fraxinus pennsylvanica*). Other common species include Sugar Maple (*Acer saccharum*), several species of oaks (*Quercus* spp.), Basswood (*Tilia americana*), Eastern Redcedar (*Juniper virginiana*), Shagbark Hickory (*Carya ovata*), and Northern Spicebush (*Lindera benzoin*) (Parks Canada 2009\*). Approximately 9% of the trees at PPNP are ashes (Koh and Spangler 2004\*): Red/Green Ash, White Ash (*Fraxinus americana*), Black Ash (*Fraxinus nigra*), and Blue Ash (*Fraxinus quadrangulata*), a COSEWIC species of "special concern" in Canada. Ashes are most common in moist interior forests and in the upper beach zone, particularly on the western side of the peninsula.

Point Pelee National Park is of great scientific value because of its unique ecological communities, the unusual geological formation of the point itself, and the intense spring migration, during which large numbers of water birds, shorebirds and passerines transit the park *en route* to their summer nesting grounds. The exceptional bird traffic is due to the park's location: Point Pelee is the first land many migrants encounter after flying north across Lake Erie (Smits 2005). The bird migration attracts thousands of birders annually, and these birders contribute significantly to the economy of the region (Hvenegaard et al. 1989).

The Emerald Ash Borer (EAB), *Agrilus planipennis* (Coleoptera: Buprestidae), is a wood-boring beetle that feeds on ash trees (*Fraxinus* spp.). Native to Asia, it was discovered in southeastern Michigan and neighboring Ontario in 2002 (McCullough and Siegert 2007). The extensive tunneling of EAB larvae under the bark kills most ash trees that become infested, from pre-reproductive trees  $\leq 5$  cm in diameter to mature trees  $> 90$  cm in diameter (OMNR 2009\*). Ash trees are among the most common trees in deciduous forests of the northeastern USA and eastern Canada; they are also widely planted as shade trees in urban areas (Sinclair and Griffiths 1994; Poland and McCullough 2006). Ash seeds are reported to be important sources of food for foraging wildlife such as Wild Turkeys (*Meleagris gallopavo*), squirrels, small rodents, quail and various songbirds (Ostfeld et al. 1997; Hulme 1998; MacGowan 2003\*).

Despite quarantines and restrictions on the movement of firewood, timber, and nursery trees, the EAB continues to expand its range. By 2009 it had been recorded as far north as Sault Ste. Marie and as far east as Ottawa and Montreal in Canada (CFIA 2009\*) and had been detected in 13 states of the USA (USDA 2009\*). The EAB has been responsible for the deaths of more than 50 million ash trees in both urban and forested areas in eastern North America (Poland and McCullough 2006; McCullough and Siegert 2007; NYSDEC 2008\*).

Invasive forest pests that kill their host trees can change bird communities. A recent example explored in the northeastern United States is the Hemlock Woolly Adelgid (*Adelges tsugae*), which has eliminated Eastern Hemlock (*Tsuga canadensis*) trees from much of the eastern United States over the past 20 years. Hemlock-dwelling species, e.g., Black-throated Green Warbler (*Dendroica virens*), Blackburnian Warbler (*Dendroica fusca*), Blue-headed Vireo (*Vireo solitarius*), and Acadian Flycatcher (*Empidonax virens*), have declined in abundance, whereas species that inhabit deciduous forests, e.g., Eastern Wood-Pewee, Great Crested Flycatcher, Red-eyed Vireo, and Wood Thrush, or more fragmented forests, e.g., Brown-headed Cowbird, Tufted Titmouse (*Baeolophus bicolor*) and White-breasted Nuthatch (*Sitta carolinensis*), have benefited from the loss of hemlock trees (Tingley et al. 2002; Ross et al. 2004; Becker et al. 2008) (scientific names of species recorded at PPNP are given in Table 1). In another study of high-elevation Red Spruce (*Picea rubens*)/Fraser Fir (*Abies fraseri*) forests in the Appalachian Mountains, the loss of conifers caused by the introduced Balsam Woolly Adelgid (*Adelges piceae*), subsequent windthrow, and air pollution changed avian communities in much the same way as fire or logging would (Rabenold et al. 1998).

Because the EAB has only recently been recognized as a pest in North America, there have been few studies on its effects on natural tree communities (Smith et al. 2006; Gandhi et al. 2008; Rebek et al. 2008) and

none quantifying the effects on birds. The biological and economic importance of birds to PPNP led us to select it as a study site to quantify the effects of the EAB on breeding bird communities. To understand these effects, baseline studies of breeding bird populations at PPNP prior to the infestation of ash trees by EAB are required. Here we report on the results of censuses conducted in 2006 and 2007 in moist interior forests of PPNP using spot-mapping techniques and review the changes in the bird fauna that may occur as the majority of ash trees at Point Pelee die within the next five years.

## Methods

### Description of Plots

Two census plots were established in the southern part of PPNP. They were chosen based on high populations of ash trees (Red/Green Ash) and nearly complete canopy cover. The two plots differed in size and shape as a result of physical and biotic features. They were large enough to include most individual territories of the species we expected to observe. The North Plot (northwest corner: NAD83 Zone 17, 41.9295305, -82.51374015), in Tilden Woods, was divided into 15 quadrats (40 m  $\times$  40 m) (Figure 1). It was the smaller of the two plots at 200 m  $\times$  120 m (2.40 ha). The South Plot (northwest corner: NAD83 Zone 17, 41.93659544, -82.51175531), located in the western segment of the Woodland Nature Trail, measured  $\sim 320$  m  $\times$   $\sim 120$  m (3.84 ha). The South Plot was divided into 24 quadrats ( $\sim 40$  m  $\times$   $\sim 40$  m) that varied slightly in size and shape on the eastern and western edges due to the presence of the Eastern Redcedar savannah habitat to the east and the road to the point to the west (Figure 2).

The North and South Plots contained 93 and 202 ash trees with trunk diameters  $\geq 10$  cm, respectively. For each tree, we recorded its location (via Garmin eTrex Legend® HCx GPS, to an accuracy of  $\pm 3$  m), diameter at breast height (dbh), and crown radius (by measuring from the edge of the crown to the trunk with a Mastercraft S7-4564-0 rangefinder). Crown radii and trunk locations were entered into ArcGIS 9.0, and the buffer feature was used to calculate the approximate area of each ash canopy. We estimated the mean percentage of ash cover in each plot by overlaying a 1 cm  $\times$  1 cm clear grid sheet on the plot map, estimating the proportion of each square covered by the crowns of ash trees, and then averaging the percentage of ash crown cover over all squares. The mean ( $\pm$  SD) diameter of the trunks of ash trees in the North Plot was  $26.5 \pm 1.65$  cm, and their crowns covered approximately 18% of the plot. The ash trees in the South Plot were more mature, larger on average (mean diameter  $41.1 \pm 1.33$  cm), and covered more (38%) of the canopy area.

Plot grid points were flagged with pink plastic tape to ensure they would be visible in the dense undergrowth. Walking routes followed previously existing



2007 Bird Census – North Plot

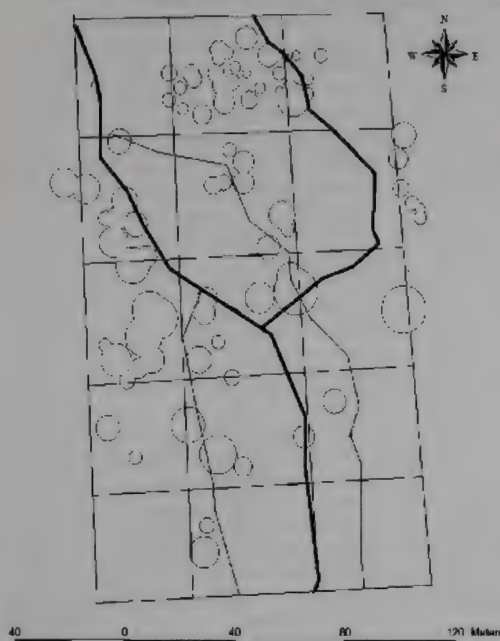


FIGURE 1. North Plot grid system, showing park trails (heavy line), footpaths (thin line) and ash tree crowns.

2007 Bird Census – South Plot

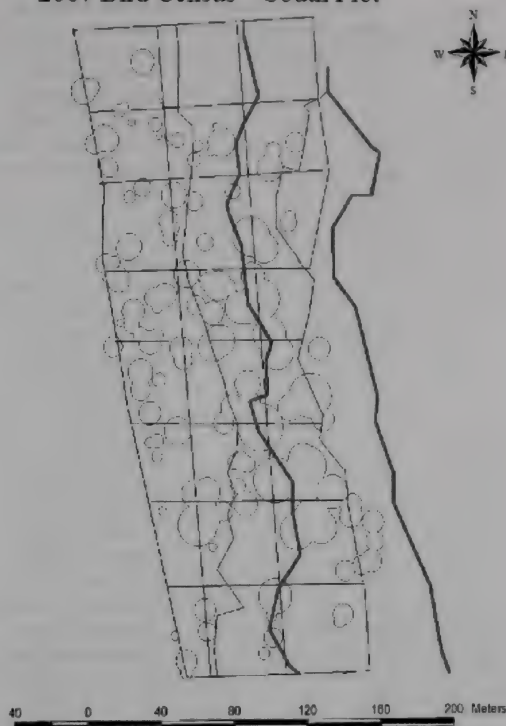


FIGURE 2. South Plot grid system showing park trails, footpaths and ash tree crowns.

woodland trails maintained by the park, where possible, and temporary foot-trails that we created. Trail maps were created using the handheld GPS unit and the computer program ArcGIS 9.0; these maps facilitated the localization of bird encounters. No point in the plot was ever more than 50 m from the observer's daily route, as recommended by Bibby et al. (2000). This permitted complete coverage of the plots.

#### *Territory Mapping Methods*

With the exception of plot size, our system of mapping bird territories followed the guidelines outlined for bird census techniques by Bibby et al. (2000). Because we selected sites with numerous ash trees, the plots were constrained in size by the distribution of the ash trees as well as by the road to the point and the Eastern Redcedar savannah habitat, with the result that our plots were smaller than the minimum plot size recommended by Bibby et al. (2000). We recorded the location and activity of all birds encountered during multiple visits to each plot. Generally, the records for each species allowed us to visualize distinct territories. Mapping simultaneously singing males and aggressive encounters was especially important in clarifying territorial boundaries. Registrations recorded just outside of plot boundaries were also considered in territory size evaluations.

It was important that our methods be standardized to allow for comparisons with future censuses. Standardi-

zation among our censuses was achieved by having one person (HDD) conduct all fieldwork throughout the study. Interpretation of the results obtained during each field season followed the rules initially set out by the International Bird Census Committee (Marchant 1983\*). As long as these same methods are followed in future censuses, it will be possible to quantify changes in the breeding bird fauna.

#### *Times and Routes*

Too many visits lead to mapping confusion; too few result in insufficient data to create reliable maps. We restricted our visits to the month of June, when birds exhibit the most territorial and nesting activity and the number of migrants is at a minimum. The British Trust for Ornithology's Common Bird Census has adopted ten visits over the entire breeding season as a standard (Marchant 1983\*). We made eight visits to each plot during the month of June.

Only one plot was censused per day. We avoided the hour before and the hour after sunrise because bird activity then was too intense to be recorded accurately. The observer maintained a slow pace when traversing the plots in order to increase the chances of detecting resident birds. Each census visit was completed in a single block of time between 0700 and 1100h on alternate weekdays. During these visits we used standard

TABLE 1. Coding used on field maps to record bird registrations, common and scientific names of all species observed in both plots, and codes for the bird species we observed (Bibby 2000).

Red	American Redstart	<i>Setophaga ruticilla</i>
R	American Robin	<i>Turdus migratorius</i>
BO	Baltimore Oriole	<i>Icterus galbula</i>
BCU	Black-billed Cuckoo	<i>Coccyzus erythrophthalmus</i>
CH	Black-capped Chickadee	<i>Poecile atricapillus</i>
BJ	Blue Jay	<i>Cyanocitta cristata</i>
COW	Brown-headed Cowbird	<i>Molothrus ater</i>
CW	Carolina Wren	<i>Thryothorus ludovicianus</i>
G	Common Grackle	<i>Quiscalus quiscula</i>
CY	Common Yellowthroat	<i>Geothlypis trichas</i>
DW	Downy Woodpecker	<i>Picoides pubescens</i>
TOW	Eastern Towhee	<i>Pipilo erythrophthalmus</i>
PW	Eastern Wood-Pewee	<i>Contopus virens</i>
GC	Great Crested Flycatcher	<i>Myiarchus crinitus</i>
Cat	Gray Catbird	<i>Dumetella carolinensis</i>
HW	House Wren	<i>Troglodytes aedon</i>
IB	Indigo Bunting	<i>Passerina cyanea</i>
MD	Mourning Dove	<i>Zenaidura macroura</i>
CA	Northern Cardinal	<i>Cardinalis cardinalis</i>
NF	Northern Flicker	<i>Colaptes auratus</i>
OO	Orchard Oriole	<i>Icterus spurius</i>
OV	Ovenbird	<i>Seiurus aurocapilla</i>
RB	Red-bellied Woodpecker	<i>Melanerpes carolinus</i>
RV	Red-eyed Vireo	<i>Vireo olivaceus</i>
RW	Red-winged Blackbird	<i>Agelaius phoeniceus</i>
RG/GR	Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>
TV	Turkey Vulture	<i>Cathartes aura</i>
V	Veery	<i>Cartharus fuscescens</i>
WF	Willow Flycatcher	<i>Empidonax traillii</i>
WT	Wood Thrush	<i>Hylocichla mustelina</i>
YW	Yellow Warbler	<i>Dendroica petechia</i>
YCU	Yellow-billed Cuckoo	<i>Coccyzus americanus</i>

symbols to represent the different types of interactions that occur between conspecifics (Bibby et al. 2000). Each species was assigned a code to enable rapid recording of all birds encountered (Table 1).

#### Creation of territory maps

Birds were identified by both sight and sound. We distinguished between bird songs (males singing on territories) and calls (contact or alarm vocalizations by males or females). Locations of vocalizing birds, birds moving between points, and interactions between individuals were plotted. After each daily census, data were transferred onto separate maps for each bird species. The final map for each species had observations combined from all visits, with the date and nature of each observation noted.

#### Analysis of data

Standard rules of territory identification and analysis (Bibby et al. 2000) were followed. Simultaneous sightings or vocalizations of two males of the same species had to be assigned to different individuals. Any active nest automatically confirmed the existence of a territory; subsequent registrations of a parent bird that flew to or from its nest further defined its territorial

boundary. A minimum of 10 days between first and last registration of a male in a particular region was also required to designate a territory. If a male was observed singing or displaying in a region for fewer than 10 days, we identified him as a migrant or non-territorial male and no territory was assigned (Bibby et al. 2000).

We estimated numbers of potentially breeding males of three non-territorial species. For Brown-headed Cowbirds, we averaged the number of male birds recorded each day over the eight observation days. We followed this same method for Red-winged Blackbirds observed in our plots, but we believe they only foraged and did not nest within the forest plots. Common Grackles presented two difficulties: they were difficult to identify by sex in the dense understory and their young had probably fledged by June (Cadman et al. 2007). For them, we present the average total number of individuals observed.

We used the Shannon index (Krebs 1989) to analyze diversity of territorial birds for each plot in each of the two years. This index is affected both by the number of territorial species (i.e., species richness) and the evenness of their abundance.



TABLE 2. Total number of bird territories located in the North and South Plots in 2006 and 2007, by species. See text for comments on three non-territorial species.

Species	North Plot		South Plot	
	2006	2007	2006	2007
American Robin	11	10	21	34
Baltimore Oriole	5	8	49	33
Black-capped Chickadee	1	1	1	0
Blue Jay	5	4	6	4
Common Yellowthroat	3	2	0	1
Downy Woodpecker	4	4	8	5
Eastern Wood-Pewee	6	3	18	14
Great Crested Flycatcher	4	2	5	7
Gray Catbird	1	0	2	0
House Wren	1	1	2	1
Mourning Dove	1	0	3	0
Northern Cardinal	2	1	3	3
Rose-breasted Grosbeak	1	1	4	5
Wood Thrush	2	1	1	0
Yellow-billed Cuckoo	2	3	3	3
Yellow Warbler	7	12	28	35
Indigo Bunting	1	0	0	0
Carolina Wren	0	0	1	4
Eastern Towhee	0	0	0	2

## Results

All bird species observed in the study plots at Point Pelee National Park are listed in Table 1, along with their mapping codes.

### North Plot

We recorded 22 species in the North Plot in 2006. Of these 22 species, there were sufficient registrations to establish a total of 57 territories (23.7 territories/ha) for 17 species (Table 2). Of the five species for which we could not establish territories, three are non-territorial: Common Grackle, Brown-headed Cowbird, and Red-winged Blackbird. The mean ( $\pm$  SD) numbers of birds of these three species were as follows: Common Grackle,  $6.1 \pm 1.8$  total individuals observed (range 1–15,  $\sim 2.5$  birds/ha); Brown-headed Cowbird,  $1.1 \pm 0.3$  males (range 1–2, 0.5 males/ha); and Red-winged Blackbird,  $2.0 \pm 1.5$  males (range 0–12, 0.8 males/ha). Although all three of these species were observed regularly, we cannot be certain that they were breeding within our plots. The other two species, Black-billed Cuckoo and the Carolina Wren, had insufficient registrations to allow territories to be designated within the plot.

Twenty-three species were recorded in the North Plot in 2007. There were sufficient registrations to establish territory maps for 14 species (Table 2), with a combined total of 53 territories (22.1 territories/ha). Nine species had indefinable territories, three of which were the same non-territorial species as in 2006 (mean  $\pm$  SD): Common Grackle,  $10.4 \pm 4.8$  total individuals observed (range 2–43,  $\sim 4.3$  individuals/ha); Brown-headed Cowbird,  $3.6 \pm 0.8$  males (range 0–7, 1.5 males/ha); and Red-winged Blackbird,  $2.3 \pm 1.2$  males (range 0–10, 1.0 males/ha). The remaining six species—Common Yellowthroat, Eastern Towhee, Gray Cat-

bird, Mourning Dove, Ovenbird and Black-billed Cuckoo—had insufficient registrations to allow territories to be determined.

### South Plot

In 2006 we recorded 21 species in the South Plot. We estimated that there was a total of 155 territories (40.4 territories/ha) for 16 species (Table 2). Of the five species for which we could not establish territories, we estimate the following numbers for the two non-territorial species (mean  $\pm$  SD): Common Grackle,  $21.9 \pm 2.4$  total individuals observed (range 11–33,  $\sim 5.7$  individuals/ha); and Brown-headed Cowbird,  $1.4 \pm 0.5$  males (range 0–3, 0.4 males/ha). The remaining three, Common Yellowthroat, Indigo Bunting and Turkey Vulture, had insufficient registrations to allow their territories to be defined.

In 2007, we recorded 28 species in the South Plot. We defined a total of 151 territories for 14 species (39.3 territories/ha) (Table 2). Fourteen species had indefinable territories: the Common Grackle, Brown-headed Cowbird and Red-winged Blackbird were non-territorial, and there were too few records to determine territories for 11 species: American Redstart, Black-billed Cuckoo, Gray Catbird, Mourning Dove, Northern Flicker, Orchard Oriole, Ovenbird, Red-bellied Woodpecker, Red-eyed Vireo, Turkey Vulture and Wood Thrush. Numbers (mean  $\pm$  SD) for the non-territorial species were as follows: Common Grackle,  $34.1 \pm 4.5$  total individuals observed (range 16–56,  $\sim 8.8$  birds/ha); Brown-headed Cowbird,  $5.6 \pm 0.9$  males (range 1–8, 1.5 males/ha); and Red-winged Blackbird,  $2.1 \pm 0.8$  males (range 0–7, 0.6 males/ha).

The Shannon diversity indices for breeding birds at the two sites over the two years ranged between 2.07 and 2.54 (Table 3). The North Plot had slightly

TABLE 3. Summary of the number of territorial species of birds recorded in the ash-rich forest plots at Point Pelee National Park. The Shannon-Wiener (S-W) indices for each plot-year are presented. See text for discussion of three non-territorial species.

Plot	Year	Number of species	Number of territories	Density of territories	S-W index
North	2006	17	57	23.7/ha	2.54
	2007	14	53	22.1/ha	2.27
South	2006	16	155	40.4/ha	2.4
	2007	15	151	39.3/ha	2.07

higher values of the index than the South Plot in both years of the study.

Discussion

We quantified the breeding birds of two mature moist forests at Point Pelee that have a moderate proportion of mature Red/Green Ash trees in order to be able to assess future effects of the EAB on the avian communities of these forests. We recorded 14–17 territorial breeding bird species plus three additional non-territorial breeding bird species, two of which we believe reproduced within our plots. There were few differences in species recorded between plots and years (Table 2). Three territorial species were by far the most common in both plots over both years: American Robin, Baltimore Oriole, and Yellow Warbler. Together they comprised 54–65% of the breeding birds in the plots. Interestingly, they are all species commonly associated with more open habitats. For unknown reasons, Baltimore Orioles were extremely abundant in the South Plot in 2006 (12.5 territories/ha); their density there in 2007 was considerably lower (8.6/ha). Fewer male Baltimore Orioles were recorded in the North Plot in 2006 and 2007 (2.1/ha and 3.3/ha, respectively). The South Plot had 70% (2006) and 78% (2007) higher density of bird territories, perhaps because it was a more mature forest with larger trees.

The relatively small size of the plots resulted in some stochastic differences among the less common species recorded (e.g., Indigo Bunting, Eastern Towhee, Common Yellowthroat, Gray Catbird, Mourning Dove). Additionally, some differences in species and relative abundances may be related to habitat differences between the plots. For example, Carolina Wrens consistently inhabited the South Plot and surrounding forest but were infrequently recorded in the North Plot; the North Plot had higher densities of American Robins than the South Plot.

Although the South Plot had approximately 75% more territories/ha in each year of study, the North Plot had higher evenness of species abundance, which led to higher values in the Shannon index in each year than in the South Plot (Table 3). The composition of the breeding bird communities in each site differed relatively little between years. Our censuses provide a solid baseline from which to assess the changes that

may occur as ash trees are killed off by the Emerald Ash Borer.

We were unable to use the census technique to estimate the density of the three non-territorial species of birds. However, by calculating the average number of each of those species recorded daily across the study period in each plot, we estimated the approximate density of these three species. Common Grackles were observed both alone and in groups. They often forage and move in groups throughout the summer, making it impossible to single out pairs (Sibley 2001). We believe they nested within both plots, but no nests were located. This could be attributed to Common Grackles fledging as early as mid-April in southern Ontario (Cadman et al. 2007). Early fledging of young and the difficulty of determining sex of birds in moving flocks further complicated estimation of breeding pairs. Because of these problems, we chose to report the mean number of Common Grackles observed without attempting to differentiate males, females, and immatures.

Brown-headed Cowbirds are promiscuous, non-territorial, and wide-ranging. During the breeding season, Brown-headed Cowbirds can be observed alone, in pairs, or in groups (Alsop 2001). Females undoubtedly laid eggs in the nests of birds breeding in our plots but that was not confirmed.

The Red-winged Blackbirds in this study were observed individually, paired and in flocks as they foraged. There was no indication that they nested in either plot.

Emerald Ash Borers were not detected in the park until the summer of 2007, when the first three dead ash trees killed by EAB were found. From initial colonization of an ash tree, it generally takes EAB ~3 years to kill a tree, but the first 1–3 years of infestation often go undetected (Poland and McCullough 2006). Therefore, it is likely that EAB had arrived at PPNP by 2004. A quick survey in 2007 documented Red/Green Ash trees infested with EAB over much of the upper beach habitat of Point Pelee (G. Otis, unpublished data). However, at the time of this study (2006 and 2007), there was no evidence that the EAB was present in our bird study plots. By February 2010, nearly all the ashes in the North Plot (50/50 trees checked) were riddled with EAB galleries and were dead. Approximately 20% (11/50 trees checked) of ash trees in the



South Plot had EAB exit holes near ground level and a few had been killed by EAB (G. Otis, unpublished data). With approximately 9% of all trees at Point Pelee being ashes (Koh and Spangler 2004\*) and 20–40% of the trees in some habitats (e.g., the plots in this study) being Red/Green Ashes, the EAB threatens to alter habitats there substantially over the coming years.

Given the rate of spread of the EAB observed elsewhere and the extreme susceptibility of Red/Green Ash trees to EAB (Anulewicz et al. 2007; Anulewicz et al. 2008; Rebek et al. 2008), we anticipate that most of the ash trees in our bird census plots will be dead or heavily infested by 2011. Once an ash tree dies, it takes only 1–3 years for the tree to fall (OMNR 2009\*), creating gaps in the forest canopy. The resulting changes in forest structure and reduction in the number of living trees providing food for birds should be associated with a general decrease in the abundance of most of the forest-breeding bird species we documented in this study. Those species that require relatively large tracts of forest, e.g., the Wood Thrush (Evans et al. 2008), may be eliminated, especially in the South Plot, where approximately 40% of the crown cover should be lost. There may be an increase in species that occur in southwestern Ontario in patchy woodland with brushy clearings: Song Sparrow (*Melospiza melodia*), Yellow-breasted Chat (*Icteria virens*), White-breasted Nuthatch, Indigo Bunting, House Wren, Carolina Wren, and White-eyed Vireo (*Vireo griseus*) (Cadman et al. 2007). Other species that may benefit temporarily from the arrival of EAB are the woodpeckers that are known to feed on EAB larvae (Lindell et al. 2008). While Downy Woodpeckers are common in the park, they may increase in numbers with the increased food supply and then decline as the total number of trees is reduced. Red-headed Woodpeckers (*Melanerpes erythrocephalus*), Red-bellied Woodpeckers, and Hairy Woodpeckers (*Picoides villosus*) may move in to feed on abundant EAB larvae. The woodpeckers in turn create nest holes that later serve as nesting sites for a number of species of cavity-nesting birds (Sibley 2001; Cadman et al. 2007). The loss of ash seeds may reduce the food supply of some species of birds, such as the Northern Cardinal (Stapanian et al. 1994), Wood Duck (*Aix sponsa*) (Schaefer et al. 2003\*), and Wild Turkey (Schroeder 1985; Dickson 1992), that breed in the park. The utilization by native bird species of ash trees as a source of food (both insects and seeds), as nest sites, and as components of the habitats required for nesting remain largely unquantified. The unfortunate arrival of the Emerald Ash Borer in Point Pelee National Park will provide an opportunity for some of these predictions to be tested by means of censuses of breeding birds at various intervals after the ash trees in these plots have died.

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# The Distribution of the Plains Spadefoot, *Spea bombifrons*, in Relation to Soil Type in Southwestern Manitoba

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The distribution of the Plains Spadefoot, *Spea bombifrons*, in southwestern Manitoba appears to be determined by soil type. Preference is shown for coarse textured to moderately textured soils, followed by medium textured soils. Drainage appeared to be less important in regard to distribution.

**Key Words:** Plains Spadefoot, *Spea bombifrons*, distribution, soil texture, Manitoba.

In southwestern Manitoba the Plains Spadefoot, *Spea bombifrons*, reaches the northeastern limit of its known range. The first collection of this species in the province consisted of three immature specimens from southwest of Dauphin (51°08'N; 100°02'W), collected 25 July 1935 by C. M. Sternberg (Cook 1960; Cook and Hatch 1964). The next known collection was by D. R. M. Hatch, southwest of Oak Lake, of a male on 22 July 1963 (Cook and Hatch 1964). In 1971 I received 6 of 18 tadpoles collected on 27 July at Oak Lake (49°46'N; 100°38'W) by J. L. C. Harrison and D. McDonald. Specimens have since been reported from, then collected at, Lyleton (49°03'N; 101°11'W) (Preston 1982; Preston and Hatch 1986), and near Virden (49°51'N; 100°55'W) (Preston and Hatch 1986). They have also been reported from the Treesbank area (49°39'N; 99°36'W) (Bredin, personal communication). During the present study spadefoots were observed near Melita (49°16'N; 100°59'W), Coulter (49°05'N; 100°59'W), and Lauder (49°23'N; 100°40'W) (the latter observation by K. De Smet, personal communication). The Lauder location was, however, not included in the study area.

The purpose of this study was to define the distribution of the Plains Spadefoot in Manitoba. Earlier, while driving slowly around the southwest part of the province one night during a steady, light rain, I noted that spadefoots were common on the roads in somewhat less than half of the area covered. The area I drove was from Melita (49°16'N; 100°59'W) to Pierson (49°10'N; 101°15'W) to Lyleton (49°03'N; 101°10'W) to Coulter (49°05'N; 100°59'W) to Waskada (49°05'N; 100°48'W) to Medora (49°15'N; 100°41'W), and back to Melita. None were seen in the area from Coulter to Waskada to Medora and from Medora to Melita (Figure 1). Weather conditions, ideal for observing spadefoots, were the same throughout. Examination of a surficial geology map of Manitoba (Map 81-1) revealed that the area where no spadefoots were seen consisted primarily of glacial till. The remainder of the area I had covered (where spadefoots were observed) con-

sisted of deposits of silt, clay and sand. This led me to wonder how critical the soil type was to spadefoot distribution. Preliminary analysis using a more detailed surficial geology map of the region (Map 39-1961 Virden) indicated that spadefoots showed a definite preference for sandy soil. As there are a variety of sandy and silty soil types in the area, I determined what particular soil types the Plains Spadefoot prefers. Bragg (1965) commented that [in Oklahoma] the Plains Spadefoot is seldom "found in regions of sandy soils" and that they "live in areas of tight soils, for the most part". He also comments on the effect of human activities (i.e., disturbance of the soil) on spadefoot distribution.

## Methods

The trips to the study area were made at random, when I could get away from my desk. The dates and the times at which the trips were made are indicated in Table 1. I drove roads at night and recorded odometer readings where spadefoots were observed, as well as at reference points such as intersections and bridges. The most fruitful nights were those with a light rain, or after a rain (both relatively uncommon in that area), if the temperature was at least 12 degrees C. However I tried to avoid being out during heavy thunderstorms or heavy rain, when visibility was greatly reduced. Bragg (1961) noted that "Spadefoot toads may remain underground for weeks at a time in dry weather...". Generally one to three field trips were made to the southwest per season, as time permitted, over several years, to collect data (Table 1). Although spadefoots were actually observed on paved or gravel roads, their presence there was assumed to be related to the soil type through which the road passed. It was also assumed that if spadefoot distribution was not related to soil type, that it would be more or less random in the area studied; i.e., the percentage of spadefoot observations in a particular soil type would be related to the percentage of the distance I travelled through that soil type, i.e. there is no relationship

TABLE 1. Observations of *Spica bombifrons* while night driving in southwest Manitoba.

Date	Time	Distance (km)	Air °C	Time	Rain	<i>S. bombifrons</i>	<i>A. cognatus</i>	<i>A. hemiophys</i>	<i>A. tigrinum</i>
5 July 1988 to 6 July 1988	2315-0155	100.4	24	0129	R <sup>1</sup>	8	0	2	0
6 July 1988 to 7 July 1988	2343-0319	155.1	21	0131	R <sup>2</sup>	4	0	0	0
25 May 1989		~90	7.4	2330		0	0	0	0
7 June 1989		95.8	7.6	2320		0	0	0	0
14 June 1989 to 15 June 1989	2235-0015	93.7	11.2	2320		0	0	0	0
26 June 1990 to 27 June 1990	2336-0200	98	19	0108	H <sup>3</sup>	24	1	2	1
28 June 1990 to 29 June 1990	0007-0234	93	21	0007		6	0	0	0
28 June 1990 to 29 June 1990	2249-0145	105	22	2200	L <sup>4</sup>	8	1	1	0
24 July 1990 to 25 July 1990	2258-0057	90	22-17	2258-0030	<sup>5</sup>	0	0	0	0
25 July 1990 to 26 July 1990	2308-0151	99.6	19	2330	S <sup>6</sup>	6	0	0	1
26 July 1990 to 27 July 1990	2240-0214	115.9	17-28	2300-0100	R <sup>7</sup>	14	1	1	4
24 June 1991 to 25 June 1991	2320-0237	135	21	2326	T <sup>8</sup>	7	2	1	0
25 June 1991 to 26 June 1991	2241-0228	177.8	18	2330	H <sup>9</sup>	21	2	0	0
18 July 1991 to 19 July 1991	2333-0133	93.9	16	2400		0	0	0	0
30 July 1991 to 31 July 1991	2258-0043	~90	17-15	2258-2328	<sup>10</sup>	0	0	0	0
8 August 1991 to 9 August 1991	2250-0025	89.1	18	2300	<sup>11</sup>	0	1	0	0
15 August 1991 to 16 August 1991	2248-0022	120.7	18	2300	L <sup>12</sup>	0	0	0	0
20 July 1993 to 21 July 1993	2340-0114	~90	16-14.2	2400-0120		0	0	0	0
21 July 1993 to 22 July 1993	2241-0041	89	19.2-19.4	2241-0041	<sup>13</sup>	1	0	0	0
3 August 1993 to 3 August 1993	2215-2359	91.5	15.6	2215		0	0	0	0
4 August 1993 to 5 August 1993	2220-0039	91.5	15-15.4	2307-0040	<sup>14</sup>	7	0	0	1
8 August 1994 to 8 August 1994	2226-2355	90.2	11	2226		0	0	0	0
9 August 1994 to 10 August 1994	2232-0041	90.4	16-17	2300-2400	L <sup>15</sup>	0	0	0	0
7 August 1996 to 7 August 1996	2215-2350	91.2	14-12	2233 2330		1	0	0	0
8 August 1996 to 8 August 1996	2157-2315	85.3	12	2230		0	0	0	0
25 trips	55 hr	~2562.1 km				107	8	7	7

<sup>1</sup> rain at 0400 hr 6 July 1988.  
<sup>2</sup> rain began at 2200 hr 6 July 1988.  
<sup>3</sup> raining hard early in the evening.  
<sup>4</sup> light rain.  
<sup>5</sup> no rain for the previous month.  
<sup>6</sup> showers at 1855 hr.  
<sup>7</sup> raining since 2130 hr.  
<sup>8</sup> thunderstorm at 2230 hr.  
<sup>9</sup> hard rain early evening, stopped 2000 hr.  
<sup>10</sup> had rained 2 days earlier.  
<sup>11</sup> had rained last 6 Aug. 1991.  
<sup>12</sup> very light rain at 2130 hr.  
<sup>13</sup> rained early am 21 July 1993.  
<sup>14</sup> light showers late afternoon.  
<sup>15</sup> a few drops of periodic rain.



between spadefoot distribution and soil type (Null Hypothesis). This was tested using the chi-square method. A detailed soil map (Eilers et al. 1978) was used to perform an in-depth analysis. These maps use aerial photographs as backgrounds. The distance travelled through each soil type was measured on the maps in millimetres, using a dial calliper, and totalled for each soil type. The number of Plains Spadefoots observed within each soil type was totalled as well. For each soil symbol (soil name, or series), in addition to surface texture, Eilers et al. (1978) provided details of drainage. For purposes of analysis, the list of 159 soil symbols (series) was reduced by combining those with the same soil texture (e.g., all those designated as loamy sand) and same drainage together, resulting in a list of 66 types, still rather cumbersome for analysis. Further combination took into account drainage only, and surface texture only (i.e., loamy sand, loamy very fine sand, etc.). Yet another list was made based on the physical surface texture such as fine textured, coarse textured, using definitions for such from Eilers et al (1978). Chi-square tests were performed on the data in these listings (Appendices I to VIII).

## Results

In Table 1 the data is presented for each night drive (25 in total) conducted in the Melita – Lyleton area of southwest Manitoba. A total of 55 hours was spent driving a total distance of 2562.1 km (in the actual study area), during which 107 *Spea bombifrons*, 8 *Anaxyrus cognatus*, 7 *Anaxyrus hemiophrys*, 7 *Ambystoma tigrinum*, and one *Lithobates sylvaticus* were observed on the roads. It will be noted that, except for one occasion when one individual was observed at an air temperature of 12°C, *Spea* was observed only at air temperatures of 15°C or higher, and especially after or during rain. On one drive N of Melita, after a light rain earlier in the day (8 August 1995), during which neither time nor mileage were noted, a number of *Lithobates pipiens* and *Ambystoma tigrinum*, perhaps 20 or so, of each, as well as two *Anaxyrus hemiophrys*, and one *Pseudacris maculata* were observed on the roads. No *Spea bombifrons* were observed in this area, however.

Analysis taking into account soil name (series), surface texture, and drainage, which included 159 categories in the study area, (Appendix I), indicated that there may be a relationship between these and spadefoot distribution. If only surface texture and drainage are taken into account, the soil names (series) having been combined under surface texture, reducing the number of categories to 66 (Appendix II), there is still an apparent relationship indicated between these and spadefoot distribution.

To determine if drainage was important, analysis was performed taking only drainage into account (Appendix III). Further analysis was performed, combining similar drainage types (Appendix V). There was ap-

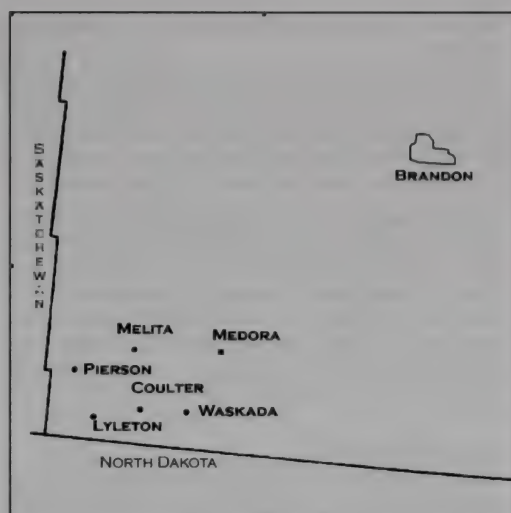


FIGURE 1. Map of southwest Manitoba indicating the study area. For scale, the distance between Melita and Medora is 35 kilometres.

parently little or no relationship between spadefoot distribution and drainage indicated.

## Discussion

The Plains Spadefoot appears to show a preference for coarse textured to moderately coarse textured soils, with 56% of the observations occurring on these soils, which occupy 36% of the transect. The next preferred category appears to be medium textured soils, which occupy 42% of the transect, and on which 31% of the observations were made. The soil types most preferred were loamy sand, which occupies 22% of the transect, with 38% of the observations, and loam, occupying 41% of the transect, with 31% of the observations. Is it the physical texture of the soil or the soil type or chemical content that is important?

These findings do not appear to concur completely with Bragg's (1965) statement about soil associations. It is not clear what Bragg meant by "tight" soils; however Clayton et al. (1977) define tight soil as "a compact, relatively impervious and tenacious soil or subsoil, which may or may not be plastic." It should be pointed out that Bragg's observations were made in Oklahoma, and it may be that spadefoot requirements differ at the north edge of their range.

Drainage appeared to have little influence on spadefoot distribution, the percentage of spadefoots observed in the different drainage types being fairly close to the percentage of the transect covered by the drainage type. The greatest preference appeared to be for imperfectly drained soils, with 51% of the observations for this type, which occupies 38% of the transects surveyed. This is perhaps to be expected in that the loamy sand soils for which this species appears to show

preference would tend to have less perfect drainage than sand.

Are the soil maps sufficiently accurate for a study of this kind? A recommendation for future research would be to collect a soil sample near the spot where each spadefoot is observed (perhaps one on each side of the road) and analyse these in regard to texture, soil type (i.e., loam, clay, etc.), and chemical content.

Knowing the preference of *Spea bombifrons* for loamy sand we can perhaps predict its distribution in southwest Manitoba, by consulting a soil map for the general area. Other than in the Dauphin area, this species appears to be limited to the Antler River-Lake Souris Plain in southwest Manitoba, bounded generally by the 450 metre contour.

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### Appendix I. *Spea* distribution in relation to Soil Type (Soil Name), Surface Texture and Drainage.

In this analysis all 159 map symbols, and combinations thereof, that occurred in the study area were used. These included Soil Name, Surface Texture and Drainage, as well as whether the soil was saline.

$H_0$ : There is no relationship between spadefoot distribution and Soil Type, Surface Texture and Drainage.

$$\text{Chi}^2 = 405.3707238$$

$$\text{df} = 159 - 1 = 158$$

$$\text{t Ratio}^1 = 10.669028$$

$$P < 0.001 \text{ (Table A., Friedman 1972)}$$

(<sup>1</sup>Calculated according to Friedman 1972, page 288)

Therefore the probability that  $H_0$  is correct is less than 0.001.

### Appendix II. *Spea* distribution in relation to Surface Texture and Drainage.

In this analysis the data were combined so that only surface texture (i.e.: loamy sand; clay; loam to clay loam; 70% loam, 30% loamy sand; etc.) and drainage were taken into account. The Soil Name (e.g. Ok, Oak Lake; Pk, Plum Creek; etc.) was not taken into account. Soils of different names but in the same surface texture and drainage categories were combined.

(<sup>1</sup>each of these was assumed to be different.)

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$H_0$ : There is no relationship between spadefoot distribution and Surface Texture and Drainage.

$$\text{Chi}^2 = 243.71175$$

$$\text{df} = 66 - 1 = 65$$

$$\text{t Ratio}^2 = 10.71985302$$

$$P < 0.001 \text{ (Table A., Friedman 1972)}$$

(<sup>2</sup>Calculated according to Friedman 1972, page 288.)

Therefore the probability that  $H_0$  is correct is less than 0.001.

### Appendix III. *Spea* distribution in relation to Drainage.

In this analysis only drainage was taken into account, i.e.: imperfect; well; poor; imperfect-poor; poor-imperfect; well-imperfect; well-poor; imperfect-well; imperfect-?; well-imperfect-poor; and well-poor-imperfect. Each of these was assumed to be different. (Compare with Appendix V.)

$H_0$ : There is no relationship between spadefoot distribution and Drainage.

$$\text{Chi}^2 = 21.234087$$

$$\text{df} = 11 - 1 = 10$$

$$0.02 > P > .01$$

Therefore the probability that  $H_0$  is correct is greater than 0.01 but less than 0.02.



#### Appendix IV. Spea distribution in relation to Surface Texture.

In this analysis all of the Surface Textures (i.e. loam; clay; loamy sand; etc.) that were the same were combined, regardless of drainage. (For further combination of Surface Textures see Appendix VI.)

$H_0$ : There is no relationship between spadefoot distribution and Surface Texture.

$$\begin{aligned}\chi^2 &= 65.169875 \\ df &= 30 - 1 = 29 \\ P &< 0.001\end{aligned}$$

Therefore the probability that  $H_0$  is correct is less than 0.001.

#### Appendix V. Spea distribution in relation to Drainage.

In this analysis some of the drainage types were combined, i.e. imperfect-poor was assumed to be the same as poor-imperfect; and well-imperfect was assumed to be the same as imperfect-well. (Compare with Appendix III.)

$H_0$ : There is no relationship between spadefoot distribution and Drainage.

$$\begin{aligned}\chi^2 &= 13.181409 \\ df &= 8 - 1 = 7 \\ 0.10 &> P > 0.05\end{aligned}$$

Therefore the probability that  $H_0$  is correct is greater than 0.05 but less than 0.10.

#### Appendix VI. Spea distribution in relation to Surface Texture.

In this analysis the various Surface Textures were further combined, however "loam" was kept separate from "loam saline". (Compare with Appendix IV.)

$H_0$ : There is no relationship between spadefoot distribution and Soil Type.

$$\begin{aligned}\chi^2 &= 55.328026 \\ df &= 17 - 1 = 16 \\ P &< 0.001\end{aligned}$$

Therefore the probability that  $H_0$  is correct is less than 0.001.

#### Appendix VII. Spea distribution in relation to soil texture.

In this analysis the Surface Textures were classified into 5 basic types, according to whether they were Coarse textured, Moderately coarse textured, Medium-textured, Moderately fine-textured, or Fine-textured (according to Eilers et al. 1978, page 197):

Coarse textured: sands, loamy sands, loamy fine sand  
Moderately coarse textured: loamy very fine sand, sandy loam, fine sandy loam  
Medium-textured: very fine sandy loam, loam, silt loam, silt, sandy clay loam (light)  
Moderately fine-textured: clay loam, silty clay loam, sandy clay loam (heavy)  
Fine-textured: sandy clay, silty clay, clay  
(Compare with Appendix VIII.)

$H_0$ : There is no relationship between spadefoot distribution and soil texture.

$$\begin{aligned}\chi^2 &= 39.69197 \\ df &= 21 - 1 = 20 \\ 0.01 &> P > 0.001\end{aligned}$$

Therefore the probability that  $H_0$  is correct is greater than 0.001 but less than 0.01.

#### Appendix VIII. Spea distribution in relation to soil texture.

In this analysis the soil textures were combined, reducing them to 6 categories:

Coarse textured to moderately coarse textured (at least 50%)  
Fine-textured  
Moderately fine textured to fine textured  
Medium textured (at least 50%)  
Moderately fine textured  
Medium textured to Moderately fine textured (at least 50%)  
(Compare with Appendix VII.)

$H_0$ : There is no relationship between spadefoot distribution and Texture.

$$\begin{aligned}\chi^2 &= 20.82427 \\ df &= 6 - 1 = 5 \\ P &< 0.001\end{aligned}$$

Therefore the probability that  $H_0$  is correct is less than 0.001.

# Diet and Prey Consumption Rates of Nesting Boreal Owls, *Aegolius funereus*, in Alaska

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Dietary composition and prey consumption rates of nesting Boreal Owls, *Aegolius funereus*, were investigated during 2004–2006 using two methods. Dietary composition was determined during nest visits through examination of 1882 fresh remains containing at least 11 mammalian and 15 avian species. Consumption rates were calculated based on laboratory examination of seven prey detritus bricks following fledging, yielding 1051 items of five different taxa. During 2003–2006, small mammal snap-trapping was conducted in the vicinity of occupied nest boxes, and relative abundance of potential prey items was estimated. A total of 4020 trap-nights yielded 695 small mammal captures of eight species. Consumption rates of nestling owls ranged from 22.0 to 29.7 g of food per day, averaging 24.2 g (SD = 1.8). Comparisons between availability of small mammals (as indicated by snap-trapping) and consumption (as indicated by nest visits and analysis of prey detritus bricks) showed that Boreal Owls are generally preying on mammals proportionate to their occurrence.

**Key Words:** Boreal Owl, *Aegolius funereus*, Alaska, consumption rate, diet, nesting, nestling, small mammals.

Knowledge of dietary requirements, both in terms of quality (species of prey) and quantity (how much prey), is an important factor in understanding the ecological niche of any animal. Numerous scientific and popular articles that provide insights into Boreal Owl, *Aegolius funereus*, diets are available. Few accounts, however, have attempted to quantify the amount of prey required to sustain life. Even fewer treatises have attempted to compare consumption rates with availability. This is an attempt not only to provide a list of species preyed upon by Boreal Owls but also to quantify that diet and to compare consumption with availability.

## Study Area

Studies were conducted during 2003–2006 in the boreal forest of interior Alaska. Nest boxes ( $n = 122$ , 34 of which were occupied during one or multiple years) were situated along primary or secondary roads within 150 km of Fairbanks, Alaska. All box routes were between 64.6°N and 65.5°N and between 146.2°W and 148.7°W. Elevations ranged from 110 to 690 m.

Overstory vegetation was highly variable. White Spruce (*Picea glauca*), often mixed with Paper Birch (*Betula papyrifera*), Eastern Larch (*Larix laricina*) or Balsam Poplar (*Populus balsamifera*), dominated lower elevations. Mid-slopes were highly variable, composed of monotypic stands of Quaking Aspen (*Populus tremuloides*), Paper Birch, or Black Spruce (*Picea mariana*), or some combination thereof. At higher elevations and on poorly drained soils, overstory vegetation was dominated by Black Spruce.

Shrub layers were often present, composed largely of willow (usually *Salix alaxensis* or *S. bebbiana*), Green Alder (*Alnus crispa*), Bog Blueberry (*Vaccinium uliginosum*), High-bush Cranberry (*Viburnum edule*), Wild Rose (*Rosa acicularis*), or Labrador Tea (*Ledum groenlandicum*). Bogs and fens, dominated by graminoids (usually *Calamagrostis* spp.) or low shrubs (Bog Blueberry or Dwarf Birch, *Betula nana*) were scattered sporadically throughout.

Interior Alaska is typified by continental weather patterns, with generally mild summers (mean July temperature of 16.9°C) and cold winters (mean January temperature of -23.4°C). Precipitation, largely in the form of June–August rains, averages 27.7 cm annually. Snow accumulations average 58 cm annually, with snow cover usually persisting until early May.

## Methods

### Diet Composition

The dietary components of the Boreal Owl diet were examined during incubation and brooding over a three-year period (2004–2006). Prey composition, generally identified to species, was done by examining fresh remains in nest boxes. Usually, prey was identifiable based on gross pelage or feather characteristics. Some specimens, however, were only identifiable based on tooth characteristics (generally soricids or young arviculines). During nest examinations where prey was documented, feet from small mammals and toes of avians were generally clipped and removed in an effort to prevent double-counting on subsequent box visits. Examination and identification of these fresh prey



remains revealed the prey items that the attendant male had delivered for consumption by the female and, following hatching, for the brood. Additional data were collected from analyses of prey detritus bricks (compacted pellets, uneaten bones and feathers, and owl mutes; Whitman 2008) removed from nest boxes post-fledging (see next section).

#### *Prey Consumption Rates*

Consumption rates were calculated based on laboratory analyses of prey detritus bricks removed from the nest boxes after the young had fledged. I assume that analyses of prey detritus bricks reflects only what the adult male delivered to the box for consumption by the brood. The adult female must be sustained as well, but I'm assuming that her brief nightly departure from the box was largely in response to her need to defecate and cast a pellet, so evidence of her consumption is not reflected in the contents of prey detritus bricks.

The collection of detritus bricks was facilitated by removing the top and front of formerly occupied boxes. The bricks were then scraped into large plastic bags with a 10-cm metal spatula. Prey bricks were frozen for at least three months before being allowed to air-dry at room temperature until mass stabilized. These detritus bricks were then meticulously separated by hand. Mammalian prey were quantified based on counts of long bones (femurs, humeri, or, most often, tibiofibulae) or mandibles, while avian identification was usually possible based on feather characteristics.

Many of the small mammals noted during nest visits were headless. Whether the male consumed the heads before delivery or whether the female removed and ingested them was not determined. Because of this, far fewer mandibles (one of the heaviest bones of small mammals) were found in the analysis of prey bricks than expected.

In calculating daily food consumption rates by Boreal Owls, I assumed that prey consumed by the brooding female was not reflected in the contents of the prey detritus brick; bricks thus reflected only what was consumed by the brood. Brood size and success (number of chicks fledged) was known from previous nest visits (Whitman 2008). For daily consumption rates, I assumed in all cases that the period from hatching to fledging was 30 days (J. Whitman, unpublished data).

Mean weights of mammalian prey items were calculated from fresh specimens taken in small mammal snap-trap lines during the study (see next section). Mean weights of avians were calculated from live weights of birds captured in mist nets during April–June by the Alaska Bird Observatory (ABO) in Fairbanks. Biomass of anurans was estimated based on weights of Wood Frogs (*Lithobates sylvaticus*) near Fairbanks (J. Whitman, unpublished data).

Comparisons of prey identification techniques (fresh prey examination in the nest boxes vs. analysis of prey

detritus bricks in the laboratory) indicated that identification of species consumed was easier and more complete based on nest box visits, whereas estimation of consumption rates was possible only through examination of detritus bricks.

#### *Small Mammal Population Indices*

Small mammal snap-trap lines were sampled annually from 2003 to 2006 in proximity to Boreal Owl nest box routes and, with the exception of soricids, are assumed to be reflective of the relative abundance of small mammals available to Boreal Owls in the area. Eight snap-trap transects were completed each July–September in a variety of habitats, and generally 100–200 trap-nights were accumulated annually per transect. Unmodified Museum Special snap-traps (Woodstream Corporation, Lititz, Pennsylvania, USA) were placed approximately 5 m apart along approximately linear transect lines and baited with a combination of peanut butter and rolled oats. Traps were run for at least two 24-hour periods and were checked each morning, at which time any captured animals were removed and the traps were reset or collected. Identification of trapped samples was done to species based on gross characteristics of size, color, and/or tooth examination. In questionable cases, specimen identifications were confirmed by personnel at the University of Alaska Museum of the North (University of Alaska Fairbanks). All small mammal specimens were deposited at the UAF Museum.

## **Results**

### *Diet Composition*

A total of 1882 specimens was examined in nest boxes during the investigation, representing food contributed by the male to both the incubating female before hatching and to the adult female and to the nestlings after hatching. As in other studies (Catling 1972; Bondrup-Nielsen 1978; Hayward 1983; Eurasian summary by Mikkola 1983; Palmer 1986; Hayward 1994; Whitman 2001, 2008), small mammals made up the vast majority of prey (Table 1). Among at least 11 species of small mammals, Northern Red-backed Voles (*Myodes rutilus*) and Tundra Voles (*Microtus oeconomus*) constituted the primary prey, in terms of both numbers and estimated biomass. During 2005, most samples in the genus *Microtus* were not examined closely enough to assign them to species, hence the large number of *Microtus* spp. (Table 1).

Collectively, avians contributed only about 6% to the biomass of the diet. At least 14 species of birds were identified (Table 1), with Dark-eyed Juncos (*Junco hyemalis*) the leading contributor numerically, but the much larger Gray Jay (*Perisoreus canadensis*) being the primary contributor in terms of biomass. Based on examinations of prey during nest visits, no frogs or insects contributed to the diet.

TABLE 1. Numbers and biomass estimates of prey taken by Boreal Owls in interior Alaska during nesting in 2004–2006 based on examination of fresh prey delivered to nest boxes.

	2004	2005	2006	Mean weight	Total prey	Total biomass	Percentage (all prey biomass)
<b>MAMMALIA</b>							
<i>Myodes (Clethrionomys) rutilus</i>	50	354	511	23.1	915	21 136.5	46.4
<i>Microtus pennsylvanicus</i>	3	10	48	25.6	61	1 561.6	3.4
<i>Microtus oeconomus</i>		17	444	27.1	461	12 493.1	27.4
<i>Microtus miurus</i>			2	22.2	2	44.4	0.1
<i>Microtus xanthognathus</i>		2	24	60.0	26	1 560.0	3.4
<i>Microtus</i> spp.	2	71		25.0	73	1 825.0	4.0
<i>Synaptomys borealis</i>		3	130	20.9	133	2 779.7	6.1
<i>Lemmus trimucronatus</i>		2	24	24.0	26	624.0	1.4
<i>Zapus hudsonius</i>		1	3	15.9	4	63.6	0.1
<i>Sorex</i> spp.	1	17	51	4.0	69	276.0	0.6
<i>Tamiasciurus hudsonicus</i>			1	70.0	1	70.0	0.2
<i>Lepus americanus</i>			3	70.0	3	210.0	0.5
Total mammals	56	477	1 241	24.0	1 774	42 643.9	93.6
<b>AVES</b>							
Dark-eyed Junco							
<i>Junco hyemalis</i>		2	19	18.2	21	382.2	0.8
Yellow-rumped Warbler							
<i>Dendroica coronata</i>		2	9	12.9	11	141.9	0.3
Wilson's Warbler							
<i>Wilsonia pusilla</i>			1	7.7	1	7.7	tr
Common Redpoll							
<i>Acanthis (Carduelis) flammea</i>		2		12.6	2	25.2	0.1
Boreal Chickadee							
<i>Poecile hudsonicus</i>			1	11.8	1	11.8	tr
Black-capped Chickadee							
<i>Poecile atricapillus</i>		9		11.6	9	104.4	0.2
Savannah Sparrow							
<i>Passerculus sandwichensis</i>			1	17.1	1	17.1	tr
White-crowned Sparrow							
<i>Zonotrichia leucophrys</i>			1	24.8	1	24.8	0.1
American Tree Sparrow							
<i>Spizella arborea</i>		1		16.6	1	16.6	tr
Fox Sparrow							
<i>Passerella iliaca</i>			2	34.3	2	68.6	0.2
Gray Jay							
<i>Perisoreus canadensis</i>		4	6	67.3	10	673.0	1.5
Hermit Thrush							
<i>Catharus guttatus</i>	1		5	27.5	6	165.0	0.4
Swainson's Thrush							
<i>Catharus ustulatus</i>			1	28.0	1	28.0	0.1
American Robin							
<i>Turdus migratorius</i>			3	76.2	3	228.6	0.5
Boreal Owl (siblicide?)							
<i>Aegolius funereus</i>	1		5	75.0	6	450.0	1.0
unidentified passerine		6	26	16.8	32	537.6	1.2
Total avian	2	26	80	26.7	108	2 882.5	6.4
TOTAL PREY	58	503	1 321	24.2	1882	45 526.4	100.0

### Prey Consumption Rates

Consumption rates are based on what is assumed to reflect the total dietary intake of Boreal Owl nestlings during the 30-day period from hatching to branching (fledging), and probably does not reflect consumption by the attendant adults. A total of seven prey detritus bricks from 2005 was analyzed from nesting

boxes following fledging of the young owls (three to six nestlings per box; Table 2). These data do not provide precise estimates of individual species consumed, but they do reveal total numbers of prey.

Consumption rates by the young owls ranged from 22.0 to 29.7 g of food per chick per day (mean 24.2 g (SD = 1.8)). This number, surprisingly, is very close



TABLE 2. Numbers and biomass estimates of prey taken by Boreal Owls in interior Alaska during nesting in 2005 based on examinations of prey detritus bricks from occupied nest boxes.

Nest Box I.D.	Number						Estimated total prey mass	Young owls fledged	Grams of prey/ nestling/day
	Voles	Flying Squirrels	Shrews	Avians	Frogs	Total			
STE04	225	0	10	1	1	237	5 346.5	6	29.7
STE09	159	0	7	3	1	170	3 899.0	5	26.0
STE10	83	0	2	1	0	86	1 981.5	3	22.0
STE29	152	2	8	3	2	167	4 036.0	6	22.4
STE30	140	0	1	4	0	145	3 386.0	5	22.6
STE31	111	0	3	2	1	117	2 674.5	4	22.3
STE32	118	0	7	4	0	129	2 893.0	4	24.1
SUM	988	2	38	18	5	1 051	24 216.5	33	169.1
MEAN	141.1	0.3	5.4	2.6	0.7	150.1	3459.5	4.7	24.2

TABLE 3. Small mammal captures in snap-traps on eight standardized lines in interior Alaska during 2003–2006.

Species	2003	2004	2005	2006	Total	Percentage of total
<i>Myodes (Clethrionomys) rutilus</i>	35	111	299	38	483	69.5
<i>Microtus pennsylvanicus</i>	3	24	39	8	74	10.6
<i>Microtus oeconomus</i>	0	0	7	8	15	2.2
<i>Synaptomys borealis</i>	1	7	9	5	22	3.2
<i>Tamiasciurus hudsonicus</i>	1	0	0	0	1	0.1
<i>Sorex cinereus</i>	17	18	44	17	96	13.8
<i>Sorex hoyi</i>	0	0	1	1	2	0.3
<i>Sorex monticolus</i>	0	0	2	0	2	0.3
Total catch	57	160	401	77	695	100.0%
Total trap-nights	957	815	1015	1233	4020	

to the estimated mean weight of each prey item delivered (23.0 g). Thus, prey deliveries and consumption equate to one prey item per chick per day. For a clutch of five Boreal Owls, approximately 150 prey items sustains them through the 30-day nestling period.

Two taxa of prey were identified from analyses of prey detritus bricks that were not documented during examination of fresh remains during box visits. Two Northern Flying Squirrels (*Glaucomys sabrinus*) and five Wood Frogs were identified from bones gleaned from prey bricks. Alternately, three neonate Snowshoe Hares (*Lepus americanus*) were identified during nest visits but were not documented through prey brick analysis. However, no prey brick analysis was done in the nest boxes where hares were documented.

#### Small Mammal Abundance

Snap-trap lines for small mammals provided an annual index of abundance of the various species. A total of 4020 trap-nights was accumulated over the four-year period, resulting in the capture of 695 small mammals. Capture rates (captures per 100 trap-nights) varied considerably annually, but varied little between sites during any particular year (Table 3). A total of 695 individuals of eight species was captured, with Northern Red-backed Voles accounting for more than half (69.5%) of the mammals captured.

#### Discussion

Information on diet was gathered in two ways. Examination of fresh-caught prey during nest box visits provided data on prey composition, but revealed little concerning the quantity consumed during the incubation/brooding period. A careful analysis of prey detritus bricks, on the other hand, yielded data that are more difficult to interpret for species of prey consumed but provide more precise estimates of numbers of prey of any particular taxon. Analysis of total consumption rates using prey bricks reveals the minimum numbers of prey consumed. Early in the brooding stage, very little is consumed by the nestlings (which weigh about 10 grams at hatching; J. Whitman, unpublished data), and it appears that the attendant female removes early detritus before it accumulates. Generally, very little prey detritus accumulates in the boxes until the oldest chick is about 10 days of age. Therefore, consumption rates reported herein should be considered bare minimums for the entire brooding period.

Comparisons of prey species selection (fresh examination during box visits) with availability (snap-trapping) indicates that Boreal Owls are small mammal specialists, but actual species of prey taken suggests that they are generalists at this level, taking an array of mammalian prey in proportion to their occurrence.

Generally, proportions of mammalian prey species were quantitatively surprisingly similar to captures in snap-traps.

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# Gap dynamics in Balsam Fir, *Abies balsamea* – Yellow Birch, *Betula alleghaniensis*, forests of Québec

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To determine if gap dynamics can play an important role in the natural regeneration process of Balsam Fir (*Abies balsamea*)-Yellow Birch (*Betula alleghaniensis*) forests and to determine the effects of gap characteristics on regenerating woody species, we sampled 119 gaps from 64 forest stands in La Mauricie National Park. Gaps averaged 184.5 m<sup>2</sup> in size. The mean gap age was 7.8 years. Gaps were usually created by broken or uprooted trees and only rarely resulted from Spruce Budworm (*Choristoneura fumiferana*) outbreaks. We found 25 species that regenerated in the gaps or under the forest cover. When considering all species, significantly more stems/ha were in gaps than under the forest cover. Gap characteristics generally did not influence regenerating woody species. We present a comprehensive model of gap dynamics in Balsam Fir-Yellow Birch forests, starting from a dense canopy, continuing with the creation and colonization of gaps, and ending to the closure of the canopy. Gap dynamics play an important role in the natural regeneration process of Balsam Fir-Yellow Birch forests.

**Key Words:** Balsam Fir, *Abies balsamea*, Yellow Birch, *Betula alleghaniensis*, gap size, gap age, gap origin, mixed forest, natural regeneration model, La Mauricie National Park, Quebec.

Afin de déterminer si la dynamique par trouée peut jouer un rôle important comme processus naturel de régénération de la sapinière à Bouleau Jaune et aussi afin de déterminer les effets des caractéristiques des trouées sur la régénération, nous avons échantillonné 119 trouées dans 64 peuplements forestiers au parc national de la Mauricie. Ces ouvertures avaient une superficie moyenne de 184,5 m<sup>2</sup>. L'âge moyen des ouvertures était de 7,8 ans. Elles étaient généralement créées par un arbre cassé ou déraciné. Peu d'ouvertures étaient créées par des épidémies de la Tordeuse des Bourgeons de l'Épinette. Au total, 25 espèces en régénération ont été rencontrées dans les ouvertures ou sous le couvert forestier. En considérant toutes les espèces, il y avait significativement plus de tiges/ha dans les ouvertures que sous le couvert forestier. Les caractéristiques des trouées n'influençaient généralement pas la régénération. Nous présentons un modèle complet sur la dynamique par trouée dans la sapinière à Bouleau jaune, commençant avec une canopée dense, continuant avec la création et la colonisation des trouées, et se terminant avec la fermeture de la canopée. La dynamique par trouée joue un rôle important dans le régime de perturbations de la sapinière à Bouleau jaune.

**Mots-clés :** Dynamique par trouée, forêt mixte, modèle de régénération naturelle, parc national de la Mauricie, sapinière à Bouleau Jaune.

In forest ecology, gap dynamics is a natural regeneration process driven by small-scale spatial disturbances (Runkle 1985). It may involve the fall of a single canopy tree, part of a canopy tree, of a very few individuals. When a canopy tree (or a part) falls, it creates a gap. A greater proportion of the light then reaches the soil surface, stimulating the regeneration of woody species. One or two trees growing in a gap will be able to reach the canopy, replacing the tree that created the gap.

Gap dynamics are found in forests around the world (Lawton and Putz 1988; Payette et al. 1990; Kohyama 1993; Abe et al. 1995). In this paper, we focus on one particular forest type, the Balsam Fir, *Abies balsamea* – Yellow Birch, *Betula alleghaniensis*, forests. The natural regeneration process of the Balsam Fir-Yellow Birch forests is very poorly understood, but the

Québec forestry manual reports that gap dynamics might be the main regeneration process of this forest type (Grondin 1996). Our first objective was to describe the characteristics of gaps in this ecosystem. We hypothesized that in mature stands, gaps are abundant. For example, based on the work of Kneeshaw and Bergeron (1998) in Quebec Balsam Fir-White Birch (*Betula papyrifera*) forests, we expected 26-32% of the forest to consist of gaps.

Our second objective was to determine the effects of gaps on the regeneration of woody species. We hypothesized that canopy species, such as Balsam Fir and Yellow Birch would have more abundant regeneration in gaps than under the forest cover. Several studies showed that these species react positively to an increased light availability (Beaudet and Messier 1998; Coates 2000; McCarthy and Weetman 2006; Webster

and Jensen 2007). We also hypothesized that the age or size of gaps could influence regenerating woody species. Knowing how long gaps last could be very useful in providing insight into the turnover rate of the mature Balsam Fir-Yellow Birch forests.

### Study Area

Balsam Fir-Yellow Birch forests cover 6% of Québec's territory, that is about 95000 km<sup>2</sup> (Grondin 1996). Along with the Balsam Fir-White Birch forests, they form the mixed forest ecosystem. The mixed forest ecosystem is characterized by the simultaneous presence of deciduous and coniferous species in the same forest stand. The mixed forest ecosystem is located between the southern deciduous forest ecosystem and the northern boreal forest ecosystem.

We conducted our study in La Mauricie National Park. The park covers an area of 536 km<sup>2</sup> and is located about 20 km northwest of Shawinigan and Grand-Mère (46°38' / 46°56' north latitude, 72°45' / 73°11' west longitude). The Saint-Maurice River forms the park's eastern border and the Mattawin River its northern border. Annual mean temperature varies from 2.8°C to 4.4°C (Service de la conservation des ressources naturelles 1981) and annual mean precipitation from 900 to 1100 mm (Robitaille and Saucier 1998). Topography within the park is characterized by hills with rounded summits with a mean altitude of 431 m.

La Mauricie National Park is found within the transition zone between the southern deciduous forest ecosystem and the northern boreal forest ecosystem (Lalumière and Thibault 1988). Forests cover 93% of the park's surface area and these can be divided into four main groups: forested peat bogs (5%), coniferous forests (21%), deciduous forests (25%) and mixed forests (49%) (Pelletier 1998). Twenty-nine tree species have been identified within the park. Balsam Fir, Red Spruce (*Picea rubens*), Sugar Maple (*Acer saccharum*), Yellow Birch, Red Maple (*Acer rubrum*) and White Birch are the most common (Service de la conservation des ressources naturelles 1981). The park was created in 1970 in order to ensure the ecological integrity of a representative piece of the Canadian Shield (Pelletier 1998). Since the park's creation, no timber harvesting has been carried out within its borders. However, the park's forests were partially harvested in the past (Pelletier 1998).

### Methods

Field work was carried out during the summer of 1999. We sampled a total of 119 gaps from 64 forest stands. We selected forest stands from a forest map (1:20000) based on their composition and age (mature). Most mature stands had an uneven structure, so age determination was not available. It is usually assumed that these stands are >90 years old. Balsam Fir-Yellow Birch was the most common stand type selected. Usually, it was pure, but accompanying species such as

Spruces, Sugar Maple and White Birch were often observed.

### Gap characteristics

We adopted three criteria in order to define gaps. First, an opening in the canopy was necessary. Second, the presence of a dead tree was required. Thirdly, regenerating woody stems had to be less than half the canopy height. We sampled only the fifth, tenth and fifteenth (if applicable) gaps, viewed from a transect passing as closely as possible to the center of each forest stand. To determine size, we measured the gap length and width. Gaps were delimited using the trunks of surrounding mature trees as the border. Gaps were thus considered according to the definition of expanded gaps proposed by Runkle (1985). The shape that best described the gaps was the ellipse.

We estimated the age of gaps by cutting three saplings in each gap. We chose stems that appeared to be the oldest in each gap. Our goal was to harvest stems that were present before the formation of the gap. These stems would have been exposed to a marked increase in available light following the gap's creation and should demonstrate a marked increase in annual growth ring width. Moisture probably did not affect the growth rings since most gaps (90%) in our study were located on dry stations (Hébert 2000). Coniferous stems were preferentially harvested since their growth rings were easier to count. We estimated the age of the gap by counting the number of larger growth rings since release (growth rings had to be at least twice as large as previous years to be counted as released). Growth rings were counted using a magnifying glass (1.75×). The age of the gap was determined using the mean age of saplings with a maximum difference of two years. Gaps where all harvested saplings demonstrated an age difference greater than two years were considered to have been created by distinct temporal events and age was not calculated. We also compared the size of gaps with known age versus those of unknown age.

We determined the origin of gaps according to three categories. The first category consisted of gaps caused by broken or uprooted trees. This designation included trees that had died from old age, broken due to deterioration, had large broken branches, or trees uprooted by wind. The second category consisted of gaps caused by insect outbreaks. Insect damage was largely caused by Spruce Budworm and resulting snags could be easily identified (still standing with a broken top). The third category consisted of gaps caused by a combination of both broken or uprooted trees and by insect outbreaks. We compared the size of gaps for each origin using Bonferroni *t*-tests.

### Effects of gaps on regenerating woody species

To sample the regenerating woody species, we opted for a paired sampling design in order to compare the vegetation in gaps to that of the surrounding forest.



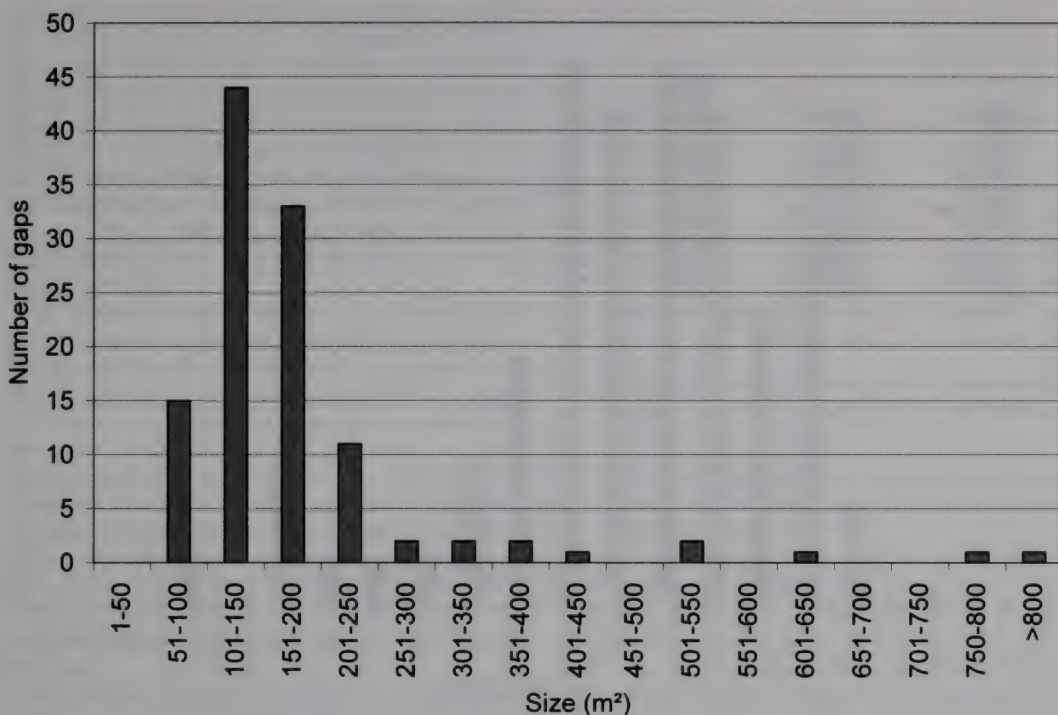


FIGURE 1. Gap size distribution in Balsam Fir-Yellow Birch forests of La Mauricie National Park, Québec.

We inventoried woody species using two plots of 1 m by 4 m positioned at the center of the halves of the longest diagonal of the gap. Two plots of 4 m<sup>2</sup> were also positioned under the forest cover. They were located 10 m from the border of the gap, in the axis of the longest diagonal of the gap. If the plots overlapped another gap, they were relocated perpendicularly to the longest gap diagonal. In each plot, all woody stems measuring over 20 cm in height were identified to species. We noted all stems having more than half of their base inside the plot and offering available twigs up to 2 m height from the ground. Spruces were not distinguished at the species level. Canadian Yew (*Taxus canadensis*) stems were counted as individual when separated above the ground.

For data analysis, we grouped the two plots of each gap together. The two corresponding plots under the forest cover were grouped as well. We used the Shapiro-Wilk test to verify data normality. Since standard transformations were unsuccessful, we used the Wilcoxon signed ranks test for paired data to compare vegetation in gaps and under the forest cover.

To determine the effects of gap characteristics on the regenerating woody species, we build a general model using an analysis of variance (ANOVA) on the number of stems and on the number of species. The analy-

sis included the size, age and origin of gaps, as well as the interactions between the variables. Statistical analyses were done with the SAS software (SAS Institute Inc 2003). We considered the results of the statistical tests significant when  $P < 0.05$ .

## Results

### Gap characteristics

The mean size of the gaps was  $184.5 \pm 14.6$  (mean  $\pm$  standard error) m<sup>2</sup>. The smallest encountered gap was 51 m<sup>2</sup> in size, whereas the largest was 1415 m<sup>2</sup> (Figure 1). However, the latter is unusual since the second largest gap measured 760 m<sup>2</sup>. Ninety percent of the gaps had a size  $\leq 250$  m<sup>2</sup> and 67% of gaps were between 101 and 200 m<sup>2</sup>.

Mean age of gaps was  $7.8 \pm 0.4$  (mean  $\pm$  standard error) years. Moreover, the majority of gaps (77%) were between 4 and 9 years old. The youngest gap encountered was 3 years old, while the oldest was 17 years old (Figure 2). We were able to estimate the age of only 73 of the 119 gaps sampled. Of the remaining gaps, we did not have enough data for 29 gaps (when coniferous stems were absent or not old enough, we still harvested deciduous stems in replacement, but we were often unable to read the growth rings in the laboratory), and 17 gaps had too much variation in the

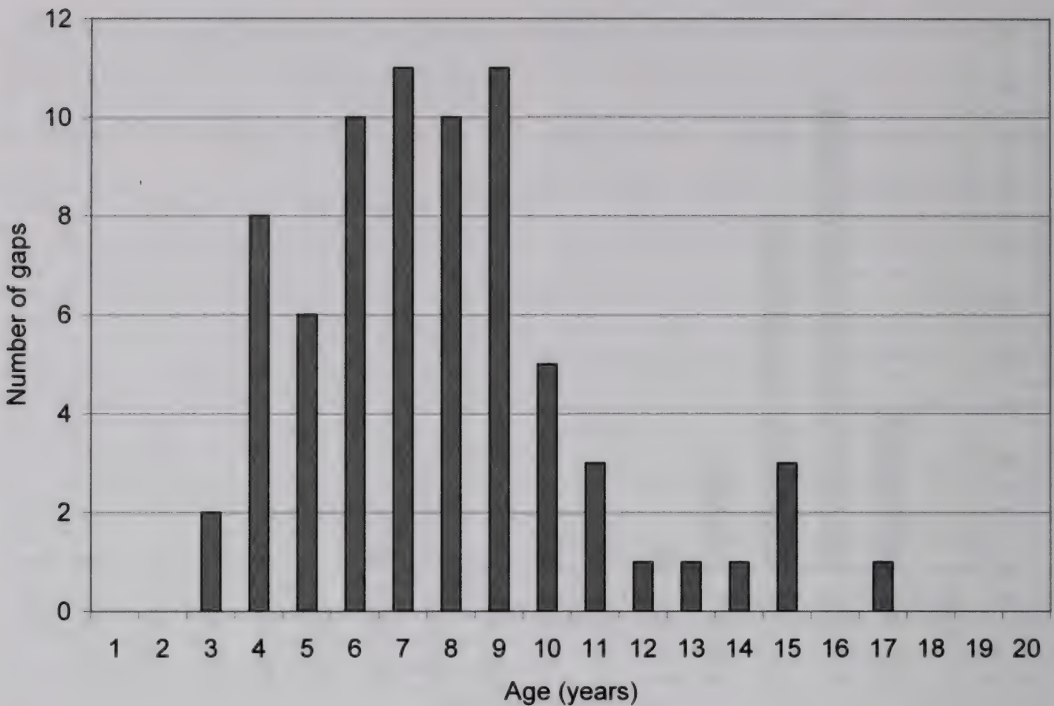


FIGURE 2. Gap age distribution in Balsam Fir-Yellow Birch forests of La Mauricie National Park, Québec.

age, which suggests that at least 14% of gaps were created from distinct temporal events. However, gap size did not significantly differ ( $Z = 0.340$ ,  $P = 0.734$ ) between gaps of known age ( $171.2 \text{ m}^2 \pm 11.9$ ,  $n = 69$ ) and gaps of unknown age ( $204.5 \text{ m}^2 \pm 31.8$ ,  $n = 46$ ). There was also no significant difference ( $Z = -1.507$ ,  $P = 0.132$ ) in gap size between 3-7 year-old gaps ( $193.6 \text{ m}^2 \pm 20.9$ ,  $n = 35$ ) and 8-17 year-old gaps ( $148.1 \text{ m}^2 \pm 9.9$ ,  $n = 34$ ).

For the origin of gaps, broken or uprooted trees were responsible for the majority of gaps (56%). The combination of broken or uprooted trees and insect outbreaks represented the second most frequent cause of gap creation (36%). Insect outbreaks alone (8%) seem to play a relatively weak role, especially when they are not in combination with broken or uprooted trees. The size of gaps did not differ significantly among origins (Figure 3). The majority of gaps resulting from insect outbreaks were, like the others, of small dimension (about two or three trees).

#### *Effects of gaps on regenerating woody species*

A total of 25 woody species was encountered in the plots (Table 1). Species such as Red Maple, Yellow Birch, Mountain Maple (*Acer spicatum*), Hobblebush (*Viburnum alnifolium*) and Beaked Hazelnut (*Corylus cornuta*), had significantly more abundant regenerating stems in gaps. Only one species, Canada Yew,

had significantly more abundant regenerating stems under the forest cover. Other species, such as Balsam Fir, Sugar Maple, White Cedar (*Thuja occidentalis*), Spruces, American Beech (*Fagus grandifolia*), Striped Maple (*Acer pensylvanicum*) and the American Fly-honeysuckle (*Lonicera canadensis*), had regenerating stems as abundant in gaps as under the forest cover. When considering all species, significantly more stems/ha were found in gaps than under the forest cover.

In general, gap characteristics did not influence the regenerating woody species (Table 2). The size, age, or origin of gaps, as well as the interactions among these variables, did not affect significantly the total number of stems found in the gaps, nor the number of species found in gaps. Gaps had a mean number of regenerating woody species of  $5.6 \pm 0.1$  (mean  $\pm$  standard error; minimum = 2 species; maximum = 9 species).

## Discussion

### *Gap characteristics*

A relatively large portion of the forest consisted of gaps, suggesting that gap dynamics play a major role in the regeneration process of Balsam Fir-Yellow Birch forests. In mixed forest stands of La Mauricie National Park, Hébert (2000) reported that gap density was  $1173.7 \pm 76.3$  (density  $\pm$  standard error) gaps/km<sup>2</sup>.



Knowing the mean size of a gap, we can now determine that gap occupied  $21.7 \pm 2.2$  (proportion  $\pm$  standard error) % of the forest area. Our result on the size of gaps and on the proportion of the forest comprised of gaps compare well with other studies done in other ecosystems (Table 3), including the study of Kneeshaw and Bergeron (1998) carried out in the Balsam Fir-White Birch domain. In our study, the fact that we had no gaps  $< 50 \text{ m}^2$  probably indicates that in Balsam Fir-Yellow Birch forests, a gap of at least  $50 \text{ m}^2$  is created when a tree dies.

The oldest gap encountered was 17 years old, suggesting that in the Balsam Fir-Yellow Birch forest, the process of gap formation and closure occurs within approximately 20 years. Runkle (1990) found that the majority of gaps were 6 years old or younger in a deciduous forest dominated by the genus *Acer* and *Fagus*. However, some gaps were up to 21 years old. Age provides a good idea of the duration of a gap, and can provide insight into the turnover rate of the mature Balsam Fir-Yellow Birch forest. With an approximate time of 20 years to reach half canopy height and a mean proportion of 21.7% of the land occupied by gaps, this suggests a full canopy turnover rate of about 184 years.

We noted that some gaps might have been created by distinct temporal events. Runkle (1985) also reported this phenomenon. For example, a gap could initially be created by only one tree fallen from the canopy. A few years later, another tree from its border could fall, thus increasing the initial size of the gap. The date of reaction (larger growth rings) of the stems in this gap created by two different episodes would differ significantly. Individual variation between stems could also explain why age was not determined for all gaps. Each stem may react differently. One may be located in a shadier part of the gap or one may stay in the shade longer than the others because of more developed stems surrounding it for example. The fact that gap size was not related to gap age indicates that gap size is probably relatively stable in Balsam Fir-Yellow Birch forests.

Three reasons could explain the weak influence of Spruce Budworm outbreaks on gap creation. The first reason is that when a coniferous tree dies, it does not clear much space in the canopy. The other deciduous trees in the canopy take advantage of the small gap by simply lengthening the branches in their crown, thus rapidly closing the opening (Runkle and Yetter 1987). The second reason why insect outbreaks do not play a larger role is that mixed stands are less susceptible to Budworm outbreak than pure Balsam Fir stands (Su et al. 1996; Cappucino et al. 1998). Finally, the third reason is that the study was not conducted in a period of severe outbreak. Results show that the majority of gaps were between 4 and 9 years old. In Québec, the last severe outbreak took place from about 1973 to 1985 (Blais 1983; Hardy et al. 1983; Gray et al. 2000).

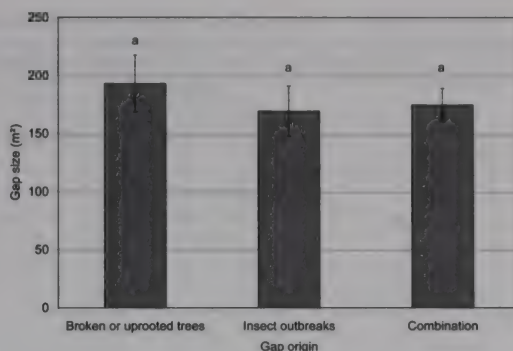


FIGURE 3. Gap size (mean  $\pm$  standard error) of gaps created by broken or uprooted trees ( $n = 64$ ), by insect outbreaks ( $n = 10$ ), and by a combination of broken or uprooted trees and insect outbreaks ( $n = 41$ ) in Balsam Fir-Yellow Birch forests of La Mauricie National Park, Québec. Means with the same letter were not significantly different.

Even though Spruce Budworm is not active solely within the context of a severe outbreak, more gaps would potentially be created during an outbreak, relatively few of these would still be visible. Kneeshaw and Bergeron (1999) also reported that the Spruce Budworm can be a factor in the creation of small gaps.

#### *Effects of gaps on regenerating woody species*

We distinguished three regeneration strategies of woody species: (1) species with more abundant regenerating stems in gaps; (2) species with more abundant regenerating stems under the forest cover; (3) species with regenerating stems as abundant in gaps as under the forest cover. Whitmore (1989), in a discussion on the general groups of forest trees, identified only the two first categories.

In general, species with more abundant regenerating stems in gaps are usually associated with light. They need a lot of light to enable seeds to germinate and for young stems to survive. As a result, gaps are beneficial by enabling the massive recruitment of new stems. Connell (1989) and Schupp et al. (1989) wrote a good discussion on the origin of colonizing species and on the challenges they must overcome. Soil resources probably also change in gaps. Our results indicated that Yellow Birch is using this strategy, where gaps enable the species to reproduce and to reach the canopy. The abundance of Yellow Birch appears relatively low in comparison to Mountain Maple, but Yellow Birch survives much longer and reaches the canopy.

We found only the Canada Yew in the category of species with more abundant regenerating stems under the forest cover. Canada Yew is a shade-demanding species (Marie-Victorin 1995). It cannot endure light and therefore does not regenerate in gaps. We even observed cases of Canadian Yew mortality in gaps.

Species with regenerating stems as abundant in gaps as under the forest cover are relatively shade tolerant.

TABLE 1. Abundance of regenerating woody species (number of stems/ha) in gaps and under the forest cover of Balsam Fir-Yellow Birch forests in La Mauricie National Park.

Species	Gap		Forest cover		Wilcoxon signed ranks test	
	Mean	Standard error	Mean	Standard error	Z	P
<i>Abies balsamea</i>	7973	811	7248	792	-0.890	0.373
<i>Acer pensylvanicum</i>	4212	883	3487	606	-0.169	0.866
<i>Acer rubrum</i>	4842	762	2458	375	-2.661	0.008
<i>Acer saccharum</i>	4338	764	3655	759	-1.339	0.181
<i>Acer spicatum</i>	16765	1396	7553	674	-5.909	0.000
<i>Amelanchier</i> sp.	336	125	273	130	-0.713	0.476
<i>Betula alleghaniensis</i>	3078	507	620	138	-5.222	0.000
<i>Betula papyrifera</i>	74	34	53	38	-0.343	0.732
<i>Cornus alternifolia</i>	53	38	0	0	-1.342	0.180
<i>Cornus stolonifera</i>	21	21	53	38	0.816	0.414
<i>Corylus cornuta</i>	4569	1024	914	260	-4.104	0.000
<i>Diervilla lonicera</i>	147	56	116	79	-0.465	0.642
<i>Fagus grandifolia</i>	368	172	252	91	-0.141	0.888
<i>Fraxinus americana</i>	11	11	0	0	-1.000	0.317
<i>Lonicera canadensis</i>	1218	318	746	163	-0.296	0.767
<i>Picea</i> sp.	578	134	672	156	0.640	0.522
<i>Sambucus pubens</i>	210	120	0	0	-2.271	0.023
<i>Shepherdia canadensis</i>	32	23	0	0	-1.342	0.180
<i>Sorbus americana</i>	189	64	74	34	-1.617	0.106
<i>Taxus canadensis</i>	4149	1134	8015	1819	2.187	0.029
<i>Thuja occidentalis</i>	1366	323	1912	446	1.087	0.277
<i>Tsuga canadensis</i>	32	23	63	36	0.647	0.518
<i>Viburnum alnifolium</i>	6733	1538	1964	483	-3.560	0.000
<i>Viburnum cassinoides</i>	42	30	32	32	0.000	1.000
<i>Viburnum edule</i>	0	0	11	11	-1.000	0.317
Coniferous stems	14098	1435	17910	1908	1.299	0.194
Deciduous stems	47238	2394	22261	1694	-8.493	0.000
All species	61336	2484	40171	2542	-6.686	0.000

TABLE 2. General model built to determine the effect of various variables on the total number of stems ( $R^2 = 0.07$ ) and on the number of regenerating woody species ( $R^2 = 0.20$ ) in gaps of Balsam Fir-Yellow Birch forests in La Mauricie National Park.

Factors	Total number of stems/ha			Number of species		
	df	F	P	df	F	P
Age of gaps (years)	1	0.14	0.71	1	0.41	0.53
Origin of gaps (see note below)	2	0.17	0.85	2	0.27	0.76
Size of gaps ( $m^2$ )	1	0.60	0.44	1	0.51	0.48
Age*Origin	2	0.08	0.92	2	0.27	0.76
Age*Size	1	0.35	0.56	1	0.78	0.38
Origin*Size	2	0.27	0.77	2	0.75	0.48
Age*Origin*Size	2	0.11	0.90	2	0.53	0.59

Note: the three possible categories for the origin of gaps were broken or uprooted trees, insect outbreaks, and a combination of the two.

Their seeds can germinate under the forest cover and young stems survive (Canham et al. 1994). However, they will never be able to reach the canopy if they remain under the forest cover (Canham 1985, 1988). These species need gaps to reach the canopy, but not to reproduce. Our results indicated that this was the case for Balsam Fir.

One important question is also to determine whether there are enough gaps to ensure the maintenance of

canopy composition. Yellow Birch lives up to 300 years. Since the turnover rate is below this life expectancy, continued recruitment of this species is possible because mature trees are likely to witness the creation of a gap to allow recruitment. For Balsam Fir, life expectancy is shorter than the turnover rate, with a life span generally close to 100 years. This could be a problem if Balsam Fir was relying on gaps to reproduce, because mature trees would not survive long



TABLE 3. Reports on gap characteristics found in the scientific literature in various forest ecosystems.

Study	Ecosystem	Gap size and proportion of the forest stands in gaps
Brokaw (1985)†	Tropical forest	Gap size = 20 m <sup>2</sup> to 705 m <sup>2</sup> .
Cumming et al. (2000)	Boreal forest	Gap size = 52 m <sup>2</sup> . Proportion = 3.6% to 16.6%.
Kneeshaw and Bergeron (1998)	Mixed forest	Proportion = 26.1% to 32.0%.
Krasny and DiGregorio (2001)	Deciduous forest	Gap size = 159 m <sup>2</sup> to 380 m <sup>2</sup> . Proportion = 19.7% to 31.9%.
Krasny and Whitmore (1992)	Deciduous forest	Gap size = 209 m <sup>2</sup> . Proportion = 20.7%.
Ott and Juday (2002)	Boreal forest	Gap size < 200 m <sup>2</sup> . Proportion, mean = 27.4%.
		Proportion, range = 18.1% to 43.9%.
Pham et al. (2004)	Boreal forest	Gap size = 75 m <sup>2</sup> to 106 m <sup>2</sup> . Proportion = 54.0%.
Runkle (1981)	Deciduous forest	Gap size, mean = 200 m <sup>2</sup> . Gap size, range = 28 m <sup>2</sup> to 2009 m <sup>2</sup> .
Runkle (1982)	Deciduous forest	Proportion, mean = 21.0%. Proportion, range = 6.7% to 47.0%.
Runkle (1990)	Deciduous forest	Gap size = 100 m <sup>2</sup> to 400 m <sup>2</sup> . Proportion = 14.1%.
Uhl et al. (1988)†	Tropical forest	Gap size < 200 m <sup>2</sup> .

† These authors used canopy gaps instead of extended gaps.

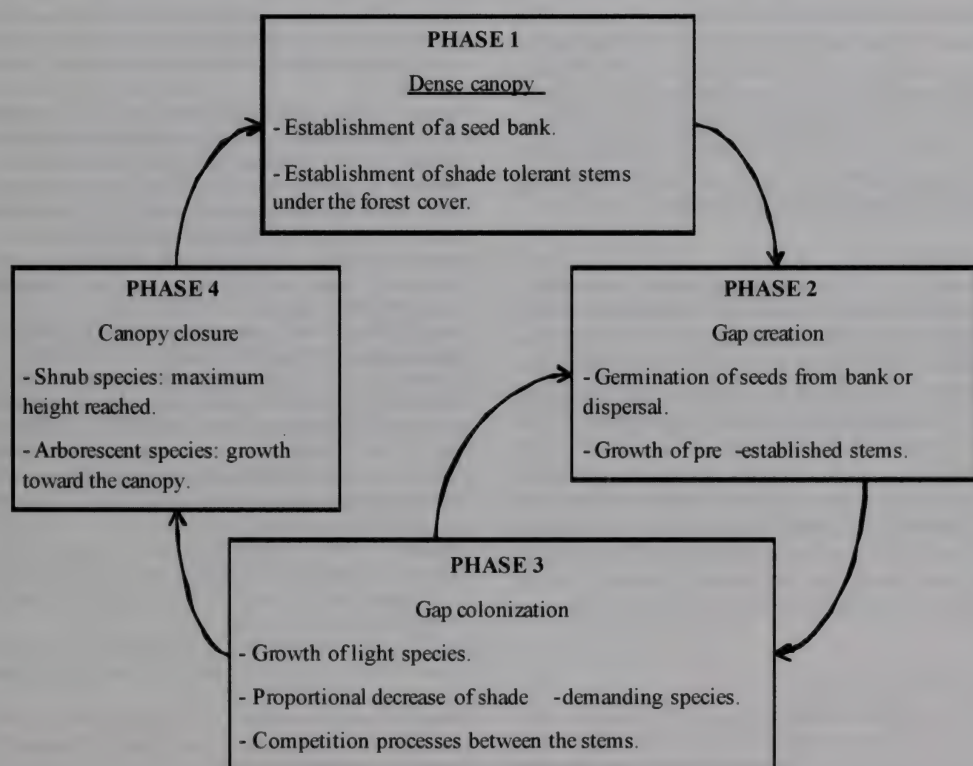


FIGURE 4. Gap dynamics model in Balsam Fir-Yellow Birch forests of La Mauricie National Park, Québec.

enough to witness the creation of a gap. However, there is Balsam Fir recruitment under the forest cover waiting for a gap to be created.

Composition of the regenerating woody species in gaps and under forest cover does not seem to be completely independent. We propose a four-step model of gap dynamics in Balsam Fir-Yellow Birch forests (Figure 4). Phase 1 takes place under the forest cover, where some stems establish. These species' seeds can

germinate under the forest cover and young stems survive. They mostly belong to the category of species with regenerating stems that are as abundant in gaps as under the forest cover. Phase 2 consists of gap creation. Here, we observe the growth of pre-established stems that were still under the forest cover at the time of the first phase. We also note germination of seeds from bank or dispersal. In phase 3, we note the proliferation of light-demanding species. These species can hardly

regenerate under the forest cover and therefore belong to the category of species with regenerating stems more abundant in gaps than under the forest cover. Shade-demanding species also decrease in gaps, thus corresponding to the category of species with regenerating stems more abundant under the forest cover than in gaps. Phase 4 is when shrub species reach their maximum height. Arborescent species then continue their growth toward the canopy. When the canopy closes, the process then repeats itself (Watt 1947). As Runkle (1985) emphasized, some stems may need more than one gap to reach the canopy, which explains the possible return from phase 3 to phase 2 that we suggested. Once back to the second gap for example, the stems have already grown considerably as opposed to the newly pre-established stems.

Brokaw and Scheiner (1989) reported that the composition of the regenerating species varies according to the size of gap, thus contributing to the biodiversity of the tropical forest. This is not the case in the Balsam Fir-Yellow Birch forests, since the size of gaps generally did not influence the composition of regenerating woody species. Vegetation within gaps also appears to be relatively stable, since gap age generally did not influence regenerating woody species.

## Conclusion

Knowledge on the natural regeneration processes of the forest ecosystems is important, especially to reduce the impacts of timber harvest. For instance, the ecosystem management approach relies on exploitation techniques that are based on the natural regeneration processes of the forest stands (Carignan and Villard 2002). In the Balsam Fir-Yellow Birch domain, our study indicates that special attention should be placed on exploitation techniques, such as partial cutting, that tend to imitate gap dynamics (Hébert 2003). Our study also reveals the importance of protected forests in national parks, since they can serve as models to better understand the natural dynamics of the forest ecosystems.

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# Home Ranges and Spatial Organization of Fishers, *Martes pennanti*, in Central British Columbia

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We described the size and spatial arrangement of aggregate and seasonal home ranges for 17 radio-tagged resident Fishers (*Martes pennanti*) that were >1.5 years old in two areas of central British Columbia during 1990-1993 and 1996-2000. We estimated home range size for each Fisher from the 95% isopleth of the utilization distribution generated using a fixed kernel model with smoothing selected by least-squares cross-validation (95% FK). For comparison to previous studies, we also calculated the minimum convex polygon estimate of home range size (MCP) for each animal. The aggregate home ranges (95% FK) of female Fishers ( $\bar{x}$  = 37.9 km<sup>2</sup>, SD = 18.5, range = 10.5 – 81.2,  $n$  = 11) were significantly smaller than those of males ( $\bar{x}$  = 161.3 km<sup>2</sup>, SD = 100.0, range = 46.0 – 225.2,  $n$  = 3;  $P$  = 0.019). We observed minor overlap among 95% FK home ranges of Fishers of the same sex, but considerable overlap among home ranges of males and females. Home ranges (95% FK or MCP) that we observed in central British Columbia were larger than those reported elsewhere in North America, particularly for males. We suggest that the distribution of resources for Fishers may occur at lower gross densities in central British Columbia than in other portions of the Fisher's range and that suitable habitat in which Fishers can establish home ranges is not found uniformly across the landscape.

**Key Words:** Fishers, *Martes pennanti*, home range, spatial organization, British Columbia.

Fishers are solitary carnivores and, other than mothers raising their young, adults interact with conspecifics usually only during mating and territorial defence (Powell 1993). Fishers are aggressive and conspecific interactions often lead to fights that are occasionally fatal (Powell 1993). The asociality of Fishers is also exhibited in their spatial organization. Fishers exhibit intrasexually exclusive home ranges, a common spacing pattern among the Mustelidae in which territories of members of the same sex rarely overlap (Kelly 1977; Powell 1979; Arthur et al. 1989).

Differential selection between the sexes in Mustelidae has resulted in different strategies of space use for each sex and, consequently, the spatial organization of the population. Moors (1980) hypothesized that male mustelids are larger than females so that they can cover large areas more quickly, and therefore encounter more females as potential mates, whereas the smaller size of females optimizes prey capture during rearing of the young (Powell 1993). To sequester sufficient resources and meet the greater energy demands of increased size, males have larger home ranges than females. This spatial organization, in combination with the size of the home range, has implications for the density of Fishers that occupy a landscape.

Powell (1994) summarized the reported sizes of home ranges of Fishers from across North America and derived a mean home range size of 15 km<sup>2</sup> for females and 38 km<sup>2</sup> for males, but found regional variation.

Estimates of home range sizes from Idaho and Montana suggest that the home range sizes of Fishers are larger in western regions than in eastern and southern areas possibly because of lower densities of prey (Idaho, Jones 1991; Montana, Heinemeyer 1993). Badry et al. (1997) found that translocated Fishers in Alberta had home ranges of 14.9 km<sup>2</sup> and 24.3 km<sup>2</sup> for females (F) and males (M) respectively, which were slightly larger home ranges than those reported for Fishers in eastern North America (e.g., Maine, 16.3 km<sup>2</sup> (F), 30.9 km<sup>2</sup> (M), Arthur et al. 1989; Massachusetts, 7.6 km<sup>2</sup> (F), 10.0 km<sup>2</sup> (M), Fuller et al. 2001; Quebec: 5.4 km<sup>2</sup> (F), 9.2 km<sup>2</sup> (M), Garant and Crête 1997).

Few studies have examined the spatial organization of Fishers in the northern half of their distribution and little is known about the sizes of home ranges of Fishers in these areas. The objectives of our study were to describe the spatial organization of Fishers and to examine effects of season and sex on space use in central British Columbia. We expect that the spatial organization and home range size of Fishers in British Columbia may differ from elsewhere because of possible differences in densities and distributions of resources, such as food or specific habitats, for Fishers. This information will be useful in estimating population densities for the Sub-Boreal Spruce Biogeoclimatic zone (Meidinger et al. 1991) and help managers determine the status of Fishers in central British Columbia.



## Study Areas

Our 1830-km<sup>2</sup> northern study area (Williston) was centred 220 km north of Prince George, British Columbia (54°1'N, 122°47'W) and lied within the moist-cool and wet-cool subzones of the Sub-Boreal Spruce Biogeoclimatic (SBS) zone to the west of the Williston Reservoir. Our 1,500-km<sup>2</sup> southern study area (Beaver Valley) lied 200 km south of Prince George entirely within the dry-warm subzone of the SBS zone. The SBS zone is a heavily forested, coniferous, montane zone dominating the landscape of the central interior of British Columbia and generally occurs from valley bottoms to about 1300 m above sea level (Meidinger et al. 1991). The climate of the SBS zone is continental and characterized by severe, snowy winters and relatively warm, moist, and short summers. Both study areas were ecologically similar: the Beaver Valley area received 536 mm of precipitation per year and had a mean annual temperature of 3.6°C (Steen and Coupé 1997); the moist-cool subzone in the Williston area received 690 mm of precipitation and had a mean annual temperature of 1.2°C (MacKinnon et al. 1990). Both of our study areas were selected, in part, because Fisher populations were low in these regions and the species was of conservation concern.

Forests in both study areas were dominated by Lodgepole Pine (*Pinus contorta* var. *latifolia*) and hybrid White Spruce (*Picea engelmannii* × *glauca*), with minor deciduous components of Trembling Aspen (*Populus tremuloides*), Paper Birch (*Betula papyrifera*), and Black Cottonwood (*Populus balsamifera trichocarpa*). Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) was a common mid- to late-successional species in the Beaver Valley study area, whereas Subalpine Fir (*Abies lasiocarpa*) was found primarily in older stands in the Williston study area. Common understory shrubs were Prickly Rose (*Rosa acicularis*), Black Huckleberry (*Vaccinium membranaceum*), Black Twinberry (*Lonicera involucrata*), Kinnikinnick (*Arctostaphylos uva-ursi*), and Black Gooseberry (*Ribes lacustre*).

The dry and moist subzones of the SBS had a natural disturbance regime of frequent, large-scale fires on a cycle of about 150 years, with most stands burning every 100 years, while the wet subzone had typical fire return intervals of greater than 250 years (British Columbia Ministry of Forests and British Columbia Ministry of Environment, Lands and Parks 1995). Forest harvesting, using a variety of techniques, had occurred over the past 40 years and created a mosaic of seral stages and stand types throughout the study areas. The entire Williston study area was forested, with no permanent human developments. Land clearing for cultivation and cattle grazing occurred extensively along most valley bottoms in the Beaver Valley study area, but accounted for less than 5% of

the land base. Harvesting of Fishers for fur was very low in both study areas with between none and three harvested by trappers per year in each study area.

## Methods

We live-trapped, radio-tagged, and monitored Fishers as part of two larger studies on the ecology of Fishers in British Columbia (Weir and Harestad 2003; Weir and Corbould 2006). We assumed that we captured and radio-tagged each resident Fisher in each study area because we intensively live-trapped each study area for Fishers during winter, conducting 3540 trapnights of live-trapping effort in the Beaver Valley area and 9234 trapnights in the Williston area. We monitored Fishers during 1990-1993 in the Beaver Valley study area and during 1996-2000 in the Williston study area. We removed a premolar 1 tooth for cementum annuli analysis (Strickland et al. 1982) from healthy Fishers to determine their year of birth. For individuals for which we were unable to extract a tooth, we classed Fishers as adults or juvenile by palpating the sagittal crest and examining tooth wear (Powell 1993).

We located Fishers using standard ground and aerial telemetry procedures (White and Garrott 1990). From the ground, we recorded directional bearings from permanent ground stations to Fishers using a three-element, collapsible Yagi antenna. We estimated radiolocations and 95% error polygons from ground telemetry using the maximum likelihood estimator (Locate II software; Nams 1990). For home range analysis, we included only those radiolocations that had 95% error polygons smaller than 0.75 km<sup>2</sup>. We observed average maximum movement rates of 728 m/h for females (SD = 812,  $n = 11$ ) and 873 m/h for males (SD = 379,  $n = 3$ ). Based upon this empirical data and approximated home range sizes of 35 km<sup>2</sup> for females and 160 km<sup>2</sup> for males, we considered that a female Fisher could reach any point within its home range within 9.2 hours and males could do so within 16.3 hours. Thus, to be slightly conservative, we considered radiolocations to be temporally independent if separated by >18 hours for either sex.

All of the Fishers radio-tagged in the Williston study area were resident individuals. Fifteen fishers (13 females, two males) were radio-collared and translocated into the Beaver Valley study area during two winters (Weir 1995). All of these Fishers were captured from ecologically similar areas (SBS and Sub-Boreal Pine Spruce biogeoclimatic zones) in the Chilcotin region (52° 30'N, 124° 38'W) and translocated into areas that were devoid of resident or transient Fishers (as determined by live-trapping). Home ranges were considered to be established for translocated animals when the mean squared distance of a set of six successive locations stabilized and no locations were made outside of the MCP of subsequent

TABLE 1. Sizes (km<sup>2</sup>) of aggregate and seasonal home ranges and core areas of radio-tagged Fishers in the Sub-Boreal Spruce Biogeoclimatic zone of central British Columbia, 1990-1993 and 1996-2000. Female home ranges denoted with an asterisk are significantly smaller than male home ranges ( $P \leq 0.05$ ).

	Male				Female			
	$\bar{x}$	SD	Range	<i>n</i>	$\bar{x}$	SD	Range	<i>n</i>
Aggregate								
95% UD <sup>a</sup>	161.3	100.0	46.0 – 225.2	3	37.9*	18.5	10.5 – 81.2	11
MCP <sup>b</sup>	144.2	57.6	77.7 – 177.8	3	52.6*	32.0	12.0 – 105.8	11
Core area <sup>c</sup>	32.9	29.6	4.8 – 63.9	3	5.1	3.6	1.2 – 13.7	11
Non-winter <sup>d</sup>								
95% UD	199.5	1.4	198.4 – 200.5	2	30.8	20.5	12.2 – 78.2	11
Core area	40.4	21.9	24.9 – 55.9	2	4.4	3.0	1.8 – 10.8	11
Winter <sup>d</sup>								
95% UD	189.7			1	51.2	23.9	16.1 – 87.8	7
Core area	30.4			1	7.0	4.4	1.1 – 13.5	7

<sup>a</sup> 95% fixed kernel utilization distribution.

<sup>b</sup> Minimum convex polygon method.

<sup>c</sup> 50% fixed kernel utilization distribution.

<sup>d</sup> Non-winter: 1 April to 14 November; winter: 15 November to 31 March.

observations used by the fisher from May-December (Weir 1995). Nine of these translocated Fishers established home ranges while in radio contact.

We estimated size and location of the home range of each resident adult (i.e., >1.5 years old) Fisher using two estimators. For Fishers with 30 or more radiolocations (Seaman et al. 1999), we estimated home ranges using the 95% isopleth of the utilisation distribution (UD) generated from the fixed kernel method with the smoothing parameter selected by least-squares cross-validation (Worton 1989). For Fishers with repeated observations at one location (i.e., natal or maternal den, rest site), we initially estimated the smoothing parameter for the fixed kernel for a dataset without the repeated observations. Using this value of the smoothing parameter, we re-ran the fixed kernel on the complete dataset. We calculated the core area of each home range using the 50% isopleth of the same distribution. To allow comparison with other studies, we also calculated aggregate home ranges using the minimum convex polygon (MCP) created from 100% of the radiolocations obtained for each Fisher. We used the Animal Movement 2.0 script for ArcView 3.x (Hooge and Eichenlaub 1999) for all home range calculations.

We classified each radiolocation into one of two seasons for estimation of seasonal home ranges. We defined the seasons as winter (15 November to 31 March) and non-winter (1 April to 14 November: includes rearing, which begins 1 April [Weir 1995]). We calculated aggregate and seasonal home ranges for each Fisher. For Fishers that we monitored for less than 1.5 seasons (i.e., <275 days), we calculated seasonal home ranges only. For those that were monitored for >1.5 seasons, we calculated seasonal and aggregate

home ranges. We pooled radiolocations across years for each Fisher for the calculation of their aggregate home range. We estimated seasonal home ranges from data collected within one season (across multiple years) for each Fisher.

We examined differences between sexes for the size of the 95% and 50% UD estimates of entire home ranges using a Mann-Whitney U-test. We investigated changes in the sizes of individual 95% UD home ranges and core areas between winter and non-winter seasons using a Wilcoxon signed rank test. We set the acceptable Type I error at 0.05.

## Results

We estimated entire, non-winter, and winter home ranges and core areas for 17 adult Fishers in the two study areas: seven Fishers (six females, one male; five translocated into area) in the Beaver Valley study area and 11 Fishers (nine females, two males) in the Williston study area. We collected between 30 and 187 radio locations for each animal ( $\bar{x} = 57$ ,  $SD = 40$ ,  $n = 17$ ).

### Aggregate Home Range

Aggregate 95% UD home ranges of female Fishers ( $\bar{x} = 37.9$  km<sup>2</sup>,  $SD = 18.5$ ,  $n = 11$ ) were significantly smaller than those of males ( $\bar{x} = 161.3$  km<sup>2</sup>,  $SD = 100.0$ ,  $n = 3$ ;  $U_{3,11} = 30$ ,  $P = 0.038$ ; Table 1). Estimates of home range area were not strongly correlated to number of radiolocations for either females (slope = -0.06,  $r^2 = 0.02$ ) or males (slope = 0.94,  $r^2 = 0.04$ ). Estimates of the aggregate MCP home ranges were also significantly smaller for females ( $\bar{x} = 52.6$  km<sup>2</sup>,  $SD = 32.0$ ,  $n = 11$ ) than males ( $\bar{x} = 144.2$  km<sup>2</sup>,  $SD = 57.6$ ,  $n = 3$ ,  $U_{3,11} = 30$ ,  $P = 0.038$ ). Aggregate core areas of females ( $\bar{x} = 5.1$  km<sup>2</sup>,  $SD = 3.6$ ,  $n = 11$ ) were smaller, but not significantly, than those of males ( $\bar{x} = 32.9$  km<sup>2</sup>,



SD = 29.6,  $n = 3$ ,  $U_{3,11} = 29$ ,  $P = 0.060$ ). Aggregate 95% UD home ranges of females were significantly smaller in the southern (Beaver Valley) study area ( $\bar{x} = 24.4$  km<sup>2</sup>, SD = 10.2,  $n = 5$ ) than the northern (Williston) study area ( $\bar{x} = 49.1$  km<sup>2</sup>, SD = 16.3,  $n = 6$ ;  $U_{5,6} = 30$ ,  $P = 0.004$ ). In both study areas, home ranges were not uniformly spread across the landscape (Figure 1).

#### Seasonal Home Range

The mean size of seasonal home ranges for females was 30.8 km<sup>2</sup> (SD = 20.5,  $n = 11$ ) during non-winter and 51.2 km<sup>2</sup> (SD = 23.9,  $n = 7$ ) during winter. The average size of the seasonal home range for males was 199.5 km<sup>2</sup> (SD = 1.4,  $n = 2$ ) during non-winter and 189.7 km<sup>2</sup> for 1 male during winter. We did not detect any significant pair-wise differences for female fishers between winter and non-winter 95% UD home ranges ( $T = 2$ ,  $n = 6$ ,  $P = 0.10$ ) or core areas ( $T = 2$ ,  $n = 6$ ,  $P = 0.10$ ).

#### Home Range Overlap

Female home ranges were generally exclusive to other females in Williston study area but less so in the Beaver Valley study area (Figure 1). In the Beaver Valley study area, the home range of one adult female (F002) was almost entirely overlapped by the home ranges of two other adult females (F006, F007), all three of which were translocated animals. Male home ranges were exclusive to other males but overlapped between one and three female home ranges in both study areas.

Overlap of home ranges among female Fishers diminished considerably when we examined core areas. In the Williston study area, we did not observe any overlap among the core areas of the females. In the Beaver Valley study area, however, approximately 40% of the core areas of F006 and F007 overlapped. Also, a small proportion of the core area of F002 overlapped with the core areas of either F006 or F007.

#### Discussion

Generally, Fishers in central British Columbia exhibited the same spatial organization that is found elsewhere in North America. The home ranges of males overlapped extensively with females and home ranges of females tended to be relatively exclusive of other females. However, the sizes and positioning of home ranges across the landscape in our study were substantially different than reported in other studies of Fishers.

The home ranges of fishers in central British Columbia were considerably larger than those recorded elsewhere in their range. Aggregate home ranges for female fishers in our study were up to 10 times larger than those reported by other researchers (e.g., 3.6 km<sup>2</sup>, Ontario, Koen et al 2007). The aggregate MCP home ranges of male Fishers in our study were up to 15 times the size estimated in other regions (e.g., 9.2 km<sup>2</sup>,

Québec, Garant and Crête 1997; 30.9 km<sup>2</sup>, Maine, Arthur et al. 1989) and were larger than any other estimate that we encountered in the literature.

The large home range sizes we observed in our study may be related to the density and distribution of resources available to Fishers. In areas with a paucity of prey, we expect home ranges would generally be larger than in areas with abundant prey (Harestad and Bunnell 1979). Thompson and Colgan (1987) found that home ranges of American Martens (*Martes americana*) in Ontario increased in size as the density of prey declined. Jones (1991) speculated that male Fishers in Idaho had large home ranges because of low prey density. Similarly, Garant and Crête (1997) hypothesized that the home ranges of Fishers in western Québec were very small because of abundant prey. Other researchers have suspected that the availability of prey for Fishers diminishes with increasing latitude, which would result in increased size of the home range (e.g., Buskirk and McDonald 1989). Indeed, home ranges of females in our northern (Williston) study area were larger than those in the Beaver Valley study area, 390 km to the south. Unfortunately, we did not assess the availability of prey so we were unable to examine the relationship between home range size and prey availability.

Prey may not be the only resource that affected the size of the home ranges of Fishers in our study. Both study areas have been subjected to considerable habitat modification through timber harvesting. Many of the life requisites of Fishers in central British Columbia appear to be linked with riparian habitats (Weir 1995), so hydro-electric flooding and possibly intensive agriculture have removed substantial portions of these habitats from the land base. Habitat alterations are likely cumulative and have changed the distribution and abundance of both prey and important habitat components across the two study areas. These changes to primary resources used by Fishers likely contributed to the spatial organization that we observed.

For sexually dimorphic carnivores such as Fishers, differences in the sizes of home ranges between sexes should be similar to differences in body mass, especially at high densities (Garant and Crête 1997). Aggregate home ranges of male Fishers in our study were 3.9 times the size of female home ranges, while male body mass was only 1.7 times that of females (R. D. Weir, unpublished data). This discrepancy in relative home range size was substantially greater than that reported for Fishers in other areas (1.5, New Hampshire, Kelly 1977; 1.9, Maine, Arthur et al. 1989; 1.8, Québec, Garant and Crête 1997).

This large discrepancy may be linked to the composition of the landscape. Many studies on the ecology of Fishers typically occur in areas with relatively high densities of Fishers (e.g., Arthur et al. 1989; Garant and Crête 1997), possibly because Fishers may be more easily captured in these areas than in areas with

low densities. In areas where home ranges of females are densely packed and resources are distributed relatively uniformly across the landscape, the ratio of home range size between the sexes appears to be closer to that predicted from body mass ratios (e.g., Garant and Crête 1997). However, in regions with sparse populations of Fishers, females may have large home ranges that are widely dispersed because resources (e.g., prey or habitat) are more rare and the distribution of areas suitable for establishing home ranges may be less uniformly distributed across the landscape. The resultant distribution would be large home ranges with considerable unused areas amongst them, such as the pattern we observed in central British Columbia, where the density of Fishers is among the lowest recorded in the literature (Weir and Corbould 2006).

Home ranges of male Fishers are larger than females because males space themselves to provide mating opportunities with several females (Powell 1994). Thus, male home ranges must be larger to find females as well as sufficient food. The more widely dispersed females and food are distributed, the larger the home range would be expected for males.

Landscape quality, which affects the distribution of resources, affects the density and arrangement of female Fishers in a population. Consequently, landscape quality indirectly affects the distribution and arrangement of males as well. We assume that, for an animal with intrasexually exclusive home ranges such as Fishers, the increase in the discrepancy between body mass ratio and home range size ratio between the sexes is indicative of landscape quality. Thus, we hypothesize that the quality of the landscape for Fishers in central British Columbia is poor relative to other regions of North America.

The differences in the degree of overlap that we noted amongst home ranges of females in the Beaver Valley study area and the Williston study area may have been caused by differences in the distribution of resources between the two areas. In the model proposed by Powell (1994), intrasexually exclusive home ranges are beneficial only at moderate levels of resource availability. When the density of a resource that affects spatial organization (e.g., food) reaches either high or low density, the cost of territoriality is greater than the benefit of exclusive use of the resource and animals will have extensive home range overlap.

The overlap of the core areas that we observed among the 3 females in the Beaver Valley study may have occurred because of a relatively high density of prey in the areas of overlap. During winter track surveys, we noted that the area of overlap had a very high density of Snowshoe Hares (*Lepus americanus*) and microtines (R. D. Weir, unpublished data) compared to elsewhere in our Beaver Valley study area. This area was unique because of the high volume of coarse woody debris, dense Douglas-fir regeneration, and relatively wet moisture regime; all habitat features

that are positively correlated with prey of Fishers. By contrast, other portions of the Beaver Valley study area and the Williston study area had much lower densities of these habitat features.

Our failure to detect changes in home range size among seasons may have been caused by several factors. Although non-winter home ranges were substantially smaller than winter home ranges for five of six females, our sample sizes were small, thus we may not have had sufficient statistical power to determine if a difference did exist. Second, a substantial difference may not exist between winter and non-winter home ranges of Fishers in our study areas. Lastly, we consolidated seasonal radiolocations from as many as three consecutive years for some females because of constraints of sample size. As shown by Arthur et al. (1989) in Maine, areas used by female Fishers vary among years. If the Fishers in our study were using distinct portions of their home range in each year, this effect would be ameliorated by our methods.

Fishers appear to occur at very low densities in portions of the Sub-Boreal Spruce Biogeoclimatic zone (Weir and Corbould 2006), despite this zone being considered among the most productive zones for Fishers in the province (Banci 1989). The Fisher density in central British Columbia is likely affected by the large home range sizes and little overlap amongst home ranges of the same sex.

Alteration of the landscape, which influences the distribution of potential home ranges, will inevitably affect the density of the Fisher population. Our findings suggest that Fishers are not distributed uniformly across the landscape and home ranges may be large because of the dispersion of mates, prey, and other habitat features. Human activities that further disperse or alter these resources may have the net effect of increasing the area needed by females to sequester sufficient resources. Alteration of the landscape may also increase the distances between female home ranges, which would increase the size of male home ranges. These two changes may result in a decrease in density of Fishers. The large size and wide dispersion of home ranges make Fishers extremely vulnerable to harvest (i.e., trapping) and to changes in habitat suitability through industrial activities such as forestry, mining, and hydroelectric development.

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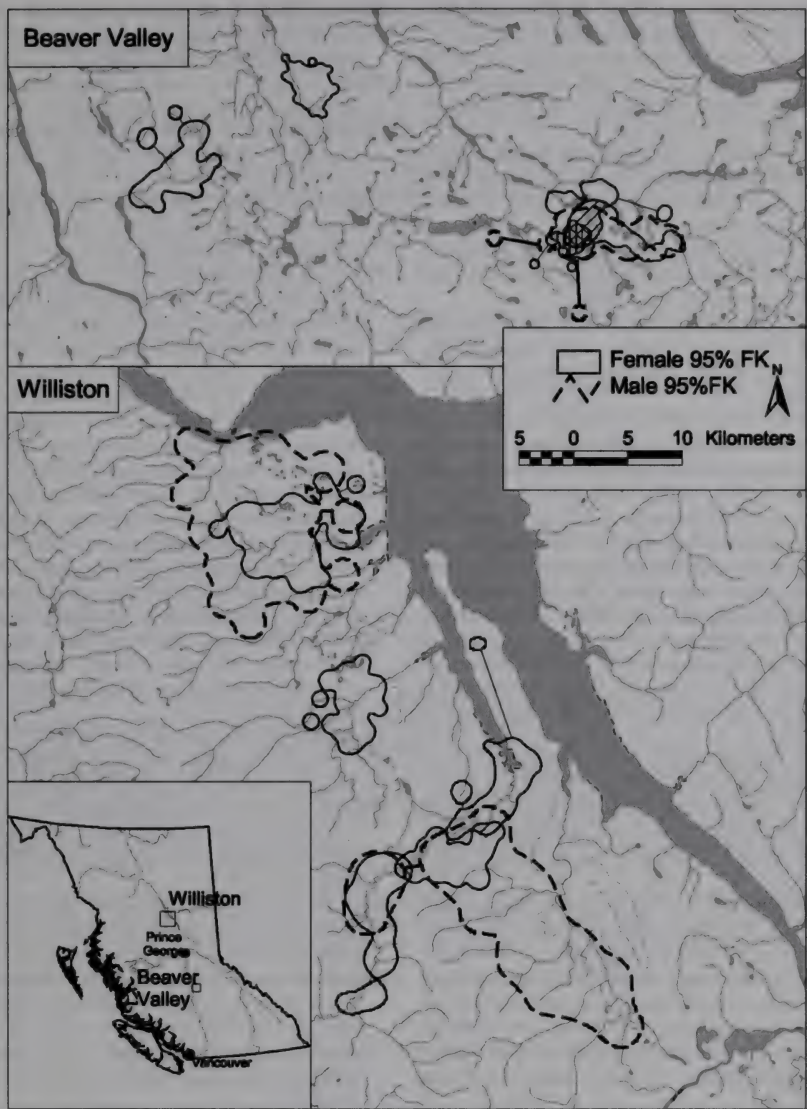


FIGURE 1. Spatial organization of aggregate 95% utilization distribution home ranges of radio-tagged Fishers in the Beaver Valley (1990-1993) and Williston (1996-2000) study areas. Identification numbers that begin with "F" are female Fishers, whereas "M" are males. Discontinuous portions of an individual's home range are connected with black lines.

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# Morphological Description of American Crow, *Corvus brachyrhynchos*, Populations in Southern Québec

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The American Crow has always been a much scrutinized bird in North America but, since the emergence of West Nile Virus (WNV) in North America in 1999, public health authorities' attention to it has been raised another notch. In Québec, like everywhere else in North America, part of the WNV surveillance programme was based on detection of WNV mortality in crow populations. During the summer of the 2005 surveillance season, we followed an age and gender determination protocol, as well as a morphological measurement protocol, on dead crows sent in for WNV status determination, to improve our knowledge of the crow population in Québec. Statistical analysis of the measurements revealed that age and gender were important factors in the morphological characterisation of the American Crow. Bill depth and head-to-bill length appeared as the most important morphological variables for gender prediction through a discriminant function analysis. We also realized that, in adult age groups, our WNV positive carcasses had lower mean weights than carcasses that tested negative for WNV, in adult age groups.

Depuis toujours, la corneille d'Amérique est un oiseau très étudié, mais, depuis l'apparition du virus du Nil occidental (VNO) en Amérique du Nord en 1999, l'attention des autorités en santé publique sur cet oiseau a encore augmenté. Au Québec, comme ailleurs en Amérique du Nord, une part importante du programme de surveillance pour la détection du VNO a été basée sur la détection des mortalités liées au VNO dans les populations de corneilles. Pour améliorer notre connaissance de cette espèce au Québec, nous avons mis à profit la récolte des carcasses au cours de l'été 2005 dans le cadre du programme de surveillance en instaurant un protocole de détermination de l'âge, du genre ainsi qu'une prise des mesures morphologiques sur ces mêmes carcasses. L'analyse statistique des résultats a montré qu'à la fois l'âge et le genre étaient des facteurs importants dans la caractérisation morphologique de la corneille d'Amérique. À l'aide de l'analyse discriminante, il est apparu que la profondeur du bec ainsi que la distance tête-bec étaient les mesures les plus importantes pour prédire le genre de l'oiseau. Nos analyses nous ont également permis d'observer que, dans les groupes d'oiseaux adultes, les carcasses positives pour le VNO étaient en moyenne moins lourdes que les carcasses négatives.

Key Words: American Crow, *Corvus brachyrhynchos*, intraspecific variations, morphological analysis, West Nile virus, age and gender effect, Quebec.

In the last century, the American Crow (*Corvus brachyrhynchos*) was the subject of research in North America (Emlen 1938; Emlen 1940; Good 1952; Johnson 1994). Interest was shown in the ecology of the species because of its important interactions with humans and crops. Other studies demonstrated the richness of crow biology by focusing on the complex social structure of the population, and on the frequent movements of crows during the year, depending on the age of an individual and the season (Verbeek and Caffrey 2002).

Since the emergence of West Nile Virus (WNV) in North America in 1999, the life history and ecology of American Crows have been scrutinized more intensely (Eidson et al. 2001a). Because the species has been found particularly susceptible to this virus (Komar et al. 2003), crows are an important epidemiological sen-

tinel for WNV in public health surveillance systems of the United States of America and of Canada (Eidson et al. 2001b; Beroll et al. 2007). Despite this increased attention from public health authorities, very little is known about crow populations in Québec, Canada, where WNV infections have been observed since 2002 in crows (Brown and Dallaire 2002\*; Health Canada 2006\*). Carcasses collected in 2005 during the province's WNV epidemiological surveillance program provided an opportunity to improve our knowledge of the crow population in Québec. A descriptive study was carried out on the carcasses of dead crows that were submitted. The objective of the study was to characterize the crow population in Québec, while taking into account the WNV status of the carcasses, by means of gender determination and external measurements on submitted carcasses.

## Materials and Methods

### *Data collection*

The carcasses were collected in southern Québec, Canada, between 6 June 2005 and 15 September 2005 during the WNV surveillance program carried out jointly by provincial and federal agencies (Québec Ministère de la sante et des services sociaux, 2005\*). People were advised to report dead or sick crows via a central telephone line, so the distribution of the carcasses sampled was dependent on human activity in a given area and motivation of the people in that area to participate in surveillance activities. Reported carcasses were collected by wildlife conservation officers and, if judged in good enough conditions, were shipped to the Centre québécois pour la santé des animaux sauvages – Canadian Cooperative Wildlife Health Center in Saint-Hyacinthe, where samples were taken for detection of WNV. A total of 332 crows were received during the sampling period. Ten crows were rejected from the study due to advanced decomposition. A direct diagnostic test (VecTest®, Medical Analysis Systems, Inc.) was performed on each carcass to determine its status for WNV. This WNV antigen detection test was chosen because of its specificity between 79% and 100% and sensitivity between 70.4% and 92.8% (Lindsay et al. 2003; Stone et al. 2004; Stone et al. 2005; Padgett et al. 2006).

### *Age determination*

Carcasses were grouped in three age classes: hatch-year birds (HY), second-year birds, i.e., birds that hatched in 2004 (SY), and after-second-year birds, i.e., birds that hatched before 2004 (ASY). Age class was determined in 322 carcasses according to the following criteria: eye colour, oral mucosa colour, feather colour, and feather shape (Emlen 1936; Good 1952; Rea 1967; Pyle 1997; Madge and Burn 1999). Colour of the iris is blue in the HY and black in the SY and the ASY. Oral mucosa is pink in the HY, is marbled pink and black in the SY and completely black in the ASY. The colour of oral mucosa was examined on both the mandible and the maxilla (floor and roof of mouth). Feather coloration is faded brown in the HY and becomes glossy black in the SY and ASY. Feather shape was also examined. In the HY, the rectrices initially have an irregular outline as well as a narrow and pointed shape. In the ASY, the rectrices become squared off or truncated with a smooth outline. Finally, the feathers of the alula (wrist of the bird) are downy and matte in the HY and glossy-black in the ASY. The morphologic characteristics corresponding to SY are intermediate between the characteristics of HY and ASY. If, for an individual carcass, some criteria pointed toward different age classes, we retained the age class indicated more frequently.

### *Morphometric measurements*

It was not possible to determine the gender and complete the morphological measurements for all of

the 322 carcasses during the limited time available at the BL3 facilities (biosecurity level). A secondary sample of 138 was selected from the 322 carcasses, using a stratified non-proportional random sample. The selected carcasses were frozen for conservation. Stratification was done according to age and WNV status. Six age-by-WNV-infection-status groups were created (HY positive, HY negative, SY positive, SY negative, ASY positive, and ASY negative). To guarantee reasonable statistical precision in further analysis, all the carcasses were kept from the HY positive group (one carcass), SY positive group (30), and ASY positive group (30). Systematic random samples were selected within the HY, SY and ASY negative groups (giving sample size of 23 carcasses for HY, and 27 for both SY and ASY groups). At this stage, we had no knowledge of the gender of carcasses within the six different age-status groups. Morphological measurements were taken on the 138 selected carcasses by one observer (Antoinette Ludwig) in order to minimize observer variability. A dial calliper and a metallic ruler were used for external measurements, and carcasses were weighted using electronic scales (Sartorius L610; precision:  $10^{-3}$  grams). If poor condition of the carcass had a negative effect on one or more of the measurements, those measurements were excluded from the analysis.

The methods of measuring the tail, bill, tarsus and wing were as described by Pyle (Pyle 1997). Flattened wing length was taken from the blunt end of the wrist joint to the tip of the longest primary feather. Tail length was measured between the tip of the longest rectrix and the point of insertion of the two central rectrices (this insertion point corresponds to the distal end of the uropygial gland). Tarsus length was measured between the intertarsal joint and the distal end of the last scale before the toes emerge. Bill length was measured as the exposed culmen, between the tip of the feathering at the base of the bill and the bill's tip. It was important to take the feathers at the base of the bill into consideration because these feathers can be rather long in the crow. Bill depth (height of the bill) and bill width (across the bill) were taken at the anterior point of the nostril. Head-to-bill length was taken from the occipital ridge of the skull to the tip of the bill. The gender of each crow was determined via necropsy after all external measurements had been recorded.

### *Statistical methods*

The frequency distribution of each morphometric variable was obtained for each gender-and-age class group and compared to the Gaussian distribution. General linear regression was performed on morphological variables using gender by age classes as the independent variable. The residual distribution for each morphological variable was studied after removing age and gender effect in order to detect non-normality. The analysis was performed using PROC GLM in SAS (9.1 – SAS Institute Inc., Cary, North Carolina, USA).





FIGURE 1: Spatial localisation of the crow carcasses collected during the 2005 West Nile Virus surveillance program in South of Québec.

The confounding effect of West Nile Virus (WNV) status on gender-and-age class group comparison was evaluated using a regression model that took into account differences in sample sizes of the gender-age-and-status groups. The dependent variables were the eight morphological variables. The values for each morphological variable were compared between both statuses in each age-and-gender groups. The analyses were performed using PROC MIXED in SAS (9.1 – SAS Institute Inc., Cary, North Carolina, USA).

We calculated our mean values and standard deviations of all the morphological variables for the 6 age and gender groups, taking into account the non-proportional stratified sampling strategy (Cochran 1977). Linear regression, taking into account differences in sample sizes of the gender-and-age class groups, was used to evaluate the effect of age, gender and age\* gender interaction (independent variables) on the eight morphological variables (dependent variables). The analyses were performed using PROC MIXED in SAS (9.1 – SAS Institute Inc., Cary, North Carolina, USA).

Discriminant analysis for gender prediction from morphological variables was developed in two steps:

variable selection and discriminant function construction. The stepwise selection procedure of the key variables for gender determination was performed using PROC STEPDISC in SAS (SAS 9.1 – SAS Institute Inc., Cary, North Carolina, USA). The analysis was performed using 0.15 as the significant level for adding variables in the forward selection mode, and the significant level for retaining variables in the backward elimination mode was set at 0.15. To create the discriminant functions we used PROC DISCRIM in SAS (SAS 9.1 – SAS Institute Inc., Cary, North Carolina, USA). Discriminant functions were built to predict the sex, both by specific age class and by all age classes confounded.

## Results

Spatial distribution of the randomly selected carcasses covered a large part of southern Québec (from the USA border to Québec city), providing a reliable overview of the morphological characteristics of the crow population from that territory (Figure 1).

The frequency distribution for the following variables did not have a completely normal distribution:

bill width and wing length for the SY and the ASY, and bill depth and tarsus length for the ASY. Using general linear regression for those variables, we found the residuals had a slightly bimodal distribution frequency, even after removing age and gender effect. This bimodal distribution frequency was most evident for wing length for the SY and the ASY groups, and tarsus length for the ASY group.

#### *Evaluation of WNV status as a confounding variable*

The tests were performed only for the SY and the ASY age classes because the number of carcasses of both positive and negative WNV status in the HY group was very low ( $N_{HY\ WNV+ \text{ female}} = 0$ ;  $N_{HY\ WNV- \text{ female}} = 5$ ;  $N_{HY\ WNV+ \text{ male}} = 1$  and  $N_{HY\ WNV- \text{ male}} = 18$ ). WNV status appeared as a significant variable for weight in the SY group ( $P$  for male = 0.0019 and  $P$  for female = 0.0003) and in the male ASY group ( $P = 0.0162$ ).

#### *Age and gender effect on the morphological variables*

The values of all morphological variables for all the six age and gender groups are presented in Figure 2. The age effect was statistically significant for all of the morphological variables. The effect of age on weight has to be considered with caution because WNV status is a potential confounding variable for weight determination by age class. The gender effect was only statistically significant for the following variables: bill depth, head-to-bill length, and weight. Regarding the mean values presented in Figure 2, gender effect corresponds to larger morphological measurements for males in comparison with females except for wing length in the HY group, and age effect corresponds to larger morphological measurements for older carcasses. The effect of interaction between age and gender was never significant (lowest  $P = 0.0941$ ).

#### *Gender prediction*

During the stepwise selection procedure of the key variables for gender prediction, no variables were retained for the HY age group. Two variables were selected for the SY age group (Bill depth ( $P = 0.0017$ ), and Head-to-bill length ( $P = 0.129$ )), and three variables were selected for the ASY age group (Head-to-bill length ( $P < 0.001$ ), Tarsus length ( $P = 0.1248$ ), and Weight ( $P = 0.1226$ )). For the total analysis performed without age-class distinction, three variables were selected: Head-to-bill length ( $P = 0.003$ ), Wing length ( $P = 0.0056$ ), and Weight ( $P = 0.0725$ ). The discriminant equations created are presented in Table 1, along with the success of classification within each age-class group, which ranges from 64.37% to 88%.

#### *Gender proportion in the dead crow population*

In the randomly sampled age-status groups, we observed that males were much more frequent than females, especially in HY age group (20.8% females in the HY group, 36.8% females in the SY group and 43.8% in the ASY group).

## Discussion

### *Evaluation of WNV status as a confounding variable*

When comparing the mean values for weight in male and female SY and ASY crows with both positive and negative WNV status, we observed that mean values were lower for carcasses positive for WNV than for those negative for WNV. As all crows in our study were picked up dead, it was difficult to know if the lower weight of the WNV positive carcasses appeared before or after their infection with WNV.

Let us consider that the weight loss preceded West Nile virus infection. In this case, weight loss could correspond to a chronic disease or a period of starvation or even coinfection of WNV and another disease that would have weakened its immune system and predisposed it to a viral infection. However, no reference currently exists in the literature in favour of such a hypothesis.

We could therefore speculate that weight loss follows WNV infection in American Crows. It has been observed that some bird species of the Passeriformes order present a lower body condition after WNV infection (Steele et al. 2000; Gibbs et al. 2005). As of yet, this observation was rare for the American Crow (Dallaire, A.D., Centre québécois pour la santé des animaux sauvages, 2007, personal communication). This is due to the acute nature of the disease in the American Crow, not allowing enough time for a change in body condition, except dehydration, that could be responsible for the weight loss (Komar et al. 2003).

However, some observations about the WNV status of wild crows, based on serological studies, suggest that this phenomenon is evolving. Serological studies conducted since 1999 have demonstrated that the proportion of crows in the population that were seropositive for WNV was increasing in North America (Gibbs et al. 2006, Ringia et al. 2004)). The two studies support the hypothesis of development of an increased capacity for resistance against West Nile Virus infection in the crow population, allowing for the possibility that resistant individuals could stay alive for a longer time after infection than has been previously observed. This phenomenon could help explain the lower weight observed in part of our adult carcasses: the more resistant adults to WNV had a longer WNV clinical period before dying allowing for the change in body condition.

### *Age and gender effect on the morphological variables*

The important results reported in Table 1 concern the role of the bill in gender differentiation in the American Crow and the role of both the bill and the tail in age differentiation in the American Crow (the older the crows were, the longer were their tails and their bills). It is already known that young crows are smaller than adult crows (Gauthier and Aubry 1995; Verbeek and Caffrey 2002). Males had a longer and a deeper bill than females, consistent with Clark's study on crows in Saskatchewan (Clark et al. 1991) and with



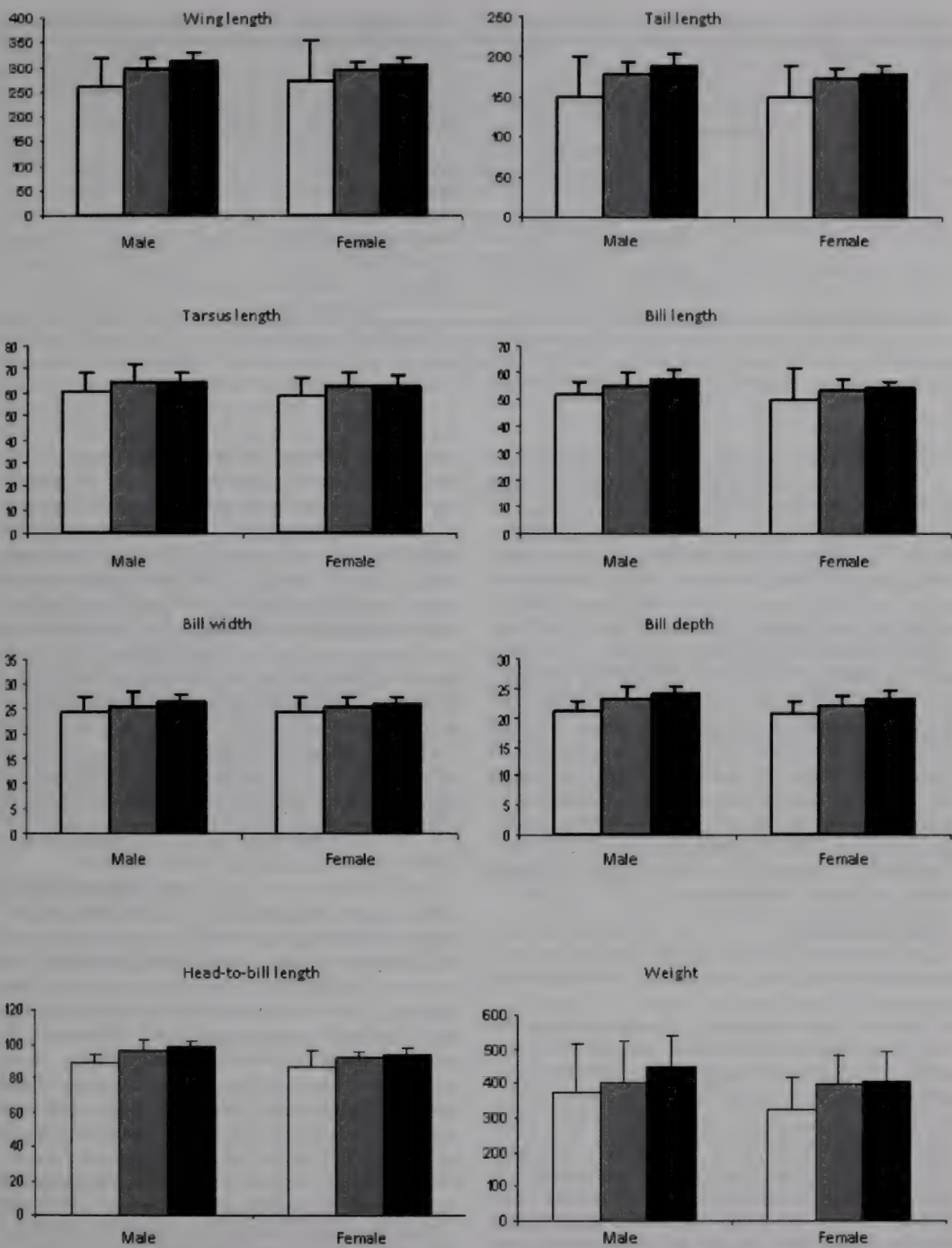


FIGURE 2 : Mean morphological values of crows from Québec within each gender and age group, in 2005.

Note: Arithmetic mean length values are given in mm and weight are given in grammes. HY, SY and ASY age groups are represented by the white, grey and black bars respectively. Sample sizes for each group are the following: 19 HY Male (1 WNV+), 5 HY Female (0 WNV+), 36 SY Male (20 WNV+), 21 SY Female (10WNV+), 32 ASY Male (16 WNV+) and 25 ASY Female (14 WNV+).

TABLE 1: Total and age-specific discriminant functions for gender determination of American Crow carcasses in Québec.

Age	Sample size	Discriminant function	Correct classification of the carcasses
SY	57	Male=-468.9136+142.61782*Bill depth+64.58749*Head-to-bill length Female=-439.19922+135.51637*Bill depth+63.10948*Head-to-bill length	69.44% 76.19%
ASY	57	Male=-871.69621+14.69643*Tarsus length+171.68221 *Head-to-bill length-0.08483*Weight Female=-800.73918+17.71192*Tarsus length+162.80922 *Head-to-bill length-0.09624*Weight	81.25% 88%
All	138	Male=-250.17699-1.39873*Wing length+60.47778 *Head-to-bill length-0.07532*Weight Female=-238.90005-1.06270*Winglength+58.46411 *Head-to-bill length-0.08124*Weight	64.37% 80.39%

Note: Substituting original measurements into both equations (for males and females) results in a score. The highest score obtained from the two discriminant functions identifies to the gender category of the carcass. HY crows were not included into the analysis because of the small size group 19 HY Male (1 WNV+), 5 HY Female (0 WNV+).

Yaremych's study on crows in Illinois (Yaremych et al. 2004). Another characteristic that has been proposed as being gender dimorphic in crows is the observation of cloacal protuberance or brood patches in females (Pyle 1997). However, these structures can be observed only during the breeding season, which is outside the period when the crows from our study were collected. In addition, these characteristics have also been reported in males due to the presence of brooding activity in both gender (Good 1952; Clark et al. 1991). The fact that interaction between age and gender was never significant demonstrated that growth was not different between sexes, and that gender dimorphism was not different between age classes. In conclusion, age and gender affect external measurements in the American Crow but growth follows a similar pattern in the male and female groups, and gender differentiation involves the same external structures regardless of the age class of the individual.

#### Gender prediction

One objective of discriminant function analysis was to find the external morphological variables that most useful in predicting the gender of a living bird. In previous studies, accounts of sexual variations in birds were limited to describing females as slightly smaller than males: the morphometric variables which differed between sexes and the extent of those differences were not precisely explained (Good 1952; Gauthier and Aubry 1995; Pyle 1997; Verbeek and Caffrey 2002). Our data provided a good opportunity to build discriminant functions for the SY and ASY age classes. It was impossible to build a discriminant function for HY age class, because of the small group size. The variables selected by discriminant analysis for the SY and the ASY age groups were the most significant when evaluating the gender effect in the crow population except for the tarsus length in the ASY. Bill length was also an important variable in gender dimorphism according to our gender effect analysis but was not conserved in the discriminant function because of

its strong association with head-to-bill length. Classification successes in gender determination of carcasses were fairly good for both age classes (more than 70% of correct classification), and were best for ASY birds (more than 81% of correct classification). This could be explained by stronger sexual dimorphism in adult crows compared with younger crows. The discriminant function built while including all carcasses (without distinguishing age class) indicated that wing length, head-to-bill length and weight were the most useful variables for gender determination. According to gender and age effect analysis, wing length, weight and head-to-bill length are variables that discriminate both for age and gender in crows. From our analysis, age emerged as a determinant variable for increasing the gender predicting precision for American Crow.

#### Gender proportion in dead crow population

Male carcasses were much more frequent than female carcasses, especially in the HY age group. No differences in survivorship and life span between male and female have been reported in the literature (Verbeek and Caffrey 2002), nor do the differences have anything to do with carcasses' WNV status, as no association has been found between WNV status and gender (A. Ludwig, unpublished data). As, in our study, the carcasses were collected by humans, we surmised that the larger number of male carcasses collected could be linked to observed but not clearly established behavioural differences between males and females: males are more reckless than females (Verbeek and Caffrey 2002), and therefore have a greater probability of dying in a human-occupied area and of being picked up as part of the surveillance program.

#### Limits

Apart from the HY female group, which consisted of only five carcasses, and the HY WNV positive group, which had only had one carcass, the number of carcasses by age class, status and gender group was large enough to allow for good statistical precision for



the mean value estimation of the morphological variables. For the two HY groups, statistical conclusion must be made with caution, because such a quasi-complete separation of the data (i.e. sparse data) can create errors in statistical tests due to small group size (Dohoo et al. 2003; Mather et al. 2007).

The objective of this study was to carry out morphometric measurements on crows from the entire province of Québec. However, this was not achieved as crows were collected during a governmental surveillance program (people phoning to signal the presence of dead birds to be picked up) rather than actively and randomly sampling across the target territory.

The crows sampled were carcasses rather than live birds. The frozen carcasses that we manipulated were not always in good condition (feathers were sometimes damaged; in some cases the internal organs were putrid). All this may have generated an underestimation for all of our measurements (information bias). As an example, the bill of a carcass in bad condition tends to come off, which makes measurements on the bill less precise. But as no gender or age specific decomposition process is known for crows, the underestimation of the measurements that could result from this phenomenon was considered to be uniform for all the carcasses, and therefore, comparisons among them continued to be acceptable.

This study emphasizes that age and gender are important factors in describing morphology of crows in Québec, as in other regions of North America (Yaremchuk et al. 2004, Clark et al. 1991). The West Nile Virus status was a confounding factor for weight comparison among the SY and ASY age groups, because the WNV positive birds seemed to be thinner than WNV negative birds in this adult group.

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# Plants and Insects New to Sable Island, Nova Scotia

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During recent inventories, particularly in 2008 and 2009, 8 plants and 17 insects were found that are additions to the flora and fauna of Sable Island, respectively. Additions to the flora include *Alnus incana* subsp. *rugosa*, *Carex nigra*, *Frangula alnus*, *Isoetes tuckermanii*, *Linaria vulgaris*, *Mertensia maritima*, *Panicum dichotomiflorum*, and *Solidago rugosa*. Additions to the insect fauna include *Apateticus bracteatus*, *Barce fraterna*, *Carabus maeander*, *Conocephalus fasciatus*, *Danaus plexippus*, *Eulithis explanata*, *Haliplus cribrarius*, *Harmonia axyridis*, *Lasioglossum novascotiae*, *Lateroligia ophiogramma*, *Lycophotia phyllophora*, *Muirodelphax arvensis*, *Nemoria rubrifrontaria*, *Neoconocephalus retusus*, *Paraphlepsius irroratus*, *Scaphytopius acutus*, and *Spilodiscus arcuatus*. The occurrence of *Spilodiscus arcuatus* is of interest with respect to an apparent decline throughout much of its range. *Neoconocephalus retusus* and species of *Catocala* provide an indication of the capability of storms to transport even large insects over substantial distances. The increasing numbers of *Danaus plexippus* observed may be part of a trend toward the northward movement of migratory insects. Some of the 7 plants are likely recent arrivals, but *Isoetes tuckermanii* and others may have been previously overlooked.

**Key Words:** Sable Island, Nova Scotia, flora, fauna, new records, climate change.

Sable Island (approximately 43.9333°N, –60.0000°W) is a remote sandy island 41 km long and up to 1.4 km wide lying in the Atlantic Ocean 161 km from the nearest mainland at Canso Head, Nova Scotia. The island has an impoverished flora and fauna but includes a number of endemic and restricted plants and animals (Howden et al. 1970; Catling et al. 1985; Wright 1989). The flora and fauna are possibly the best enumerated of any wild part of Canada, and the island provides an unusual opportunity to study ecology and evolution under isolated conditions.

The history of botanical exploration (notably surveys by John Macoun in 1899; Hans Güssow in 1911; Harold St. John in 1913; John Erskine in 1952; and the team of Paul Catling, Bill Freedman and Zoe Lucas in 1981, reported in Freedman et al. (1982) and in Catling et al. (1985)), and the flora of the island up to 2002 were reviewed by Stalter and Lamont (2006) and Stalter et al. (2006), who reported that the native island flora has remained relatively stable over the past century and the non-native flora has not increased. The terrestrial fauna of Sable Island has been compiled and reviewed by Wright (1989). That comprehensive list included 500 species of insects and made reference to an earlier compilation (Howden et al. 1970). Dragonflies new to the island fauna, including *Ischnura hastata*, *Tramea carolina*, and *Tramea lacerata*, were reported recently (Catling et al. 2009).

Studies of the ecology, evolution, and dynamics of the unusual and isolated island flora are continuing, so current information on composition is needed. Here

we provide information on species of plants and insects that are newly reported on the island based on survey work during late July and August 2008 and late August 2009, unless otherwise stated. Voucher specimens have been deposited in the Agriculture Canada National Plant Collection in Ottawa (acronym DAO), the vascular plant herbarium of the University of Michigan (acronym MICH), and the National Collection of Insects at Agriculture and Agri-Food Canada in Ottawa (acronym CNCI). Plants are listed alphabetically by family and within family. Insects are listed alphabetically by order and within order.

## Additional Vascular Plants

### ASTERACEAE

*Solidago rugosa* P. Mill. subsp. *rugosa*, Wrinkle-leaf Goldenrod

A single patch approximately 1 m in diameter was found in open *Ammophila* grassland inside the horse enclosure fence at the Fisheries and Oceans Canada field camp near East Light (43.96037°N, –59.7848°W). Possibly always present but very rare and previously overlooked.

### BETULACEAE

*Alnus incana* (L.) Moench subsp. *rugosa* (DuRoi) Clausen, Speckled Alder

A single shrub 1 m tall on the edge of a slope beside a moist area with *Juncus balticus* on the north side of the Sable Island Station compound (previously known

as the weather station) (43.93392°N, -60.01522°W). The site was protected from wind by surrounding dunes and buildings. This plant may be an overlooked remnant of a tree planting attempt in 1901.

#### BORAGINACEAE

*Mertensia maritima* (L.) S.F. Gray var. *maritima*, Oysterleaf

A specimen was collected on 26 July 2009 on the upper beach slope, along the edge of a beach grass foredune, north beach, west of West Light (approximately 43.93555°N, -60.03854°W). The stems and foliage covered an area of about 30 × 30 cm. Other small patches were observed on the north beach of West Spit.

#### CYPERACEAE

*Carex nigra* (Linnaeus) Reichard, Smooth Black Sedge

Tall (to 4 m), slender plants were abundant in two low natural meadows with *Vaccinium macrocarpon* and *Juncus balticus* on the west side of the station compound (43.9332°N, -60.0137°W). A clump approximately 0.5 m<sup>2</sup> of small (to 4 cm tall) but robust plants was found in open sand on a sandy ridge near West Light (43.9309°N, -60.0228°W). Although fairly conspicuous, this species is localized and could have been overlooked in previous surveys. Infrataxa of *Carex nigra* are not recognized in North America, but the specimens from Sable Island represent unusual extremes.

#### ISOETACEAE

*Isoetes tuckermanii* A. Braun ex Engelmann in A. Gray, Spiny Spore Quillwort

Thousands of plants were found in water 1–2 m deep in sandy substrate of Gallinule Pond (43.9323°N, -59.8986°W). In some places, the plants occurred with *Myriophyllum tennellum*. Although this species was abundant at this location, we believe that it could have been overlooked in previous surveys due to its inconspicuous occurrence in relatively deep water (over 1 m). It occurred only in this one pond based on an inventory of all ponds on the island during the summer of 2008. In this one location it was abundant and dominant in 1–2 m of water and covered the entire bottom. Based on the size of this pond, it is possible that half a million plants were present. Some of the plants were unusually large, with leaves 20–25 cm in length.

#### POACEAE

*Panicum dichotomiflorum* Michx., Fall Panic Grass

Robust plants were found around the edges of saline ponds west of the station (approximately 43.9304°N, -60.0252°W). These pond margins were formerly well vegetated and fresh, but incursions of sea water have killed much of the original vegetation, resulting in

sandy and muddy flats where numerous plants of this species were observed. It seems likely that this is a recent arrival.

#### RHAMNACEAE

*Frangula alnus* P. Mill. (*Rhamnus frangula*), Glossy False Buckthorn

Two of these introduced shrubs 0.4 m tall were found on the edge of a slope at the station (same location as *Alnus incana* subsp. *rugosa* above, and possibly also an overlooked remnant of the tree planting attempt in 1901).

#### SCROPHULARIACEAE

*Linaria vulgaris* P. Mill., Greater Butter-and-eggs

This alien species was found inside the horse enclosure fence at the Fisheries and Oceans Canada field camp near East Light (43.95961°N, -59.78294°W) and is unknown elsewhere on the island. Since it is a conspicuous species, it seems likely that it was not overlooked previously but is a recent introduction.

#### Additional Insects

##### COLEOPTERA

*Carabus maeander* Fischer (Carabidae)

This species was first collected on the island by Z. Lucas at the West Ponds on 29 June 2005. It is normally associated with marshes, and on Sable Island one was taken in a pitfall trap in wet sand at the edge of a freshwater pond.

*Haliplus cribrarius* LeConte (Haliplidae) (Figure 1)

Three specimens were found in ponds 10 (43.93187°N, -60.02377°W) and 16 (43.93198°N, -59.96898°W) in early August 2008. This species is much less common on the island than the smaller *Haliplus immaculicollis* Harris, which was found in eight ponds.

*Harmonia axyridis* Pallas (Coccinellidae), Asian Lady Beetle

A single specimen was found on a dead bird on the south beach on 29 July 2007. This species was introduced to North America to control aphids and it has recently spread widely.

*Spilodiscus (Hister) arcuatus* Say (Histeridae) (Figure 1)

Ten were collected on sand on a south-facing beach ridge on 23 June 2008. This species is known from dunes on the Atlantic coast from the east coast of Chesapeake Bay north to Nova Scotia and less commonly inland on dunes to Lake Michigan (Caterino 1998). In Canada it is known only from Nova Scotia, having been collected at Pictou and at Clam Harbour (Bousquet and Laplante 2006). Caterino (1998) suggested that it has not been collected in the USA (most of its range) since the 1950s, and the only exception





FIGURE 1. Insects recently found on Sable Island that were not recorded in earlier entomological surveys. From left to right: *Spilodiscus (Hister) arcuatus* Say (Coleoptera: Histeridae), *Haliphus cribrarius* LeConte (Coleoptera: Halipidae), and *Barce fraterna* Say (Hemiptera: Reduviidae).

to this appears to be a recent collection from Block Island, Rhode Island (Sikes 2007), which appears to be a refugium for a number of beetles that have been extirpated from the mainland. The more recent (1968, 1998, 2008) Canadian records suggest that the northern more disjunct populations may not have declined as much as those to the south.

#### HEMIPTERA

*Apateticus bracteatus* (Fitch) (Hemiptera: Pentatomidae)

Eight specimens were found in heath land near the station on 19–26 August 2009.

*Barce fraterna* Say (Hemiptera: Reduviidae), Thread-legged Bug (Figure 1)

Two specimens were found in a space below a piece of wood on 13 August 2008.

#### HOMOPTERA

*Muirodelphax arvensis* (Fitch) (Delphacidae)

Thirty individuals were found in grassland sweep net samples from outside horse enclosures at the station.

*Paraphlepsius irroratus* (Say) (Cicadellidae)

Five individuals were found in heath land sweep net samples at the station.

*Scaphytopius acutus* (Say) (Cicadellidae)

Fifty-five individuals were found in sweep net samples from heath land vegetation at the station.

#### HYMENOPTERA

*Lasioglossum (Dialictus) novascotiae* Mitchell (Apidae)

Several specimens were collected in various parts of the island, mostly on flowers of *Achillea millefolium* and *Polygonum hydropiperoides*. Specimens determined by Jason Gibbs are in the collection of L. Packer at York University. This species is very similar to *L. lineatulum*, which has previously been reported for the island (Wright 1989).

#### LEPIDOPTERA

*Danaus plexippus* (Linnaeus) (Lepidoptera: Nymphalidae), Monarch

Although Monarchs are not common in the Maritimes, they have been reported from southern Newfoundland (Layberry et al. 1998), so the lack of a record earlier than 1999 from Sable Island is surprising. Even more surprising is the fact that during autumn 1999 thousands of Monarchs were seen on Sable Island. It is estimated that there were more than 10 000 on the island during the last two weeks of September. Up to 100 were present on individual plants of flowering Seaside Goldenrod (*Solidago sempervirens*). On 26 September 2006, there were again hundreds of Monarchs on the island. Since then, several have been seen every year during July–September. In 2008, three were seen in early August in the central part of the island. The increasing numbers of Monarchs

observed suggests that migratory insects are moving north, as is suggested by recent observations of migratory dragonflies on Sable Island (Catling et al. 2009).

*Eulithis explanata* (Walker) (Lepidoptera: Geometridae), White Eulithis

Five specimens were collected at lights at the station in July and early August. The larvae are said to feed on *Vaccinium* (Handfield 1999), two species of which are abundant on this island.

*Lateroligia ophiogramma* (Esper) (Lepidoptera: Noctuidae)

This relatively recent introduction from Europe was collected near the station in late July 2008.

*Lycophotia phyllophora* (Grote) (Lepidoptera: Noctuidae)

Eight specimens of this native species, likely associated with heath lands, were collected near the station in late July 2008.

*Nemoria rubrifrontaria* (Packard) (Lepidoptera: Geometridae), Red-fronted Emerald

Eight specimens were captured west of the station on 27 June 2008. Ferguson (1985) suggests that species of *Myrica* are the preferred food plants, and on Sable Island it is suspected that the food plant is the abundant *Myrica pensylvanica*.

## ORTHOPTERA

*Conocephalus fasciatus* (De Geer) (Conocephalidae)

Five specimens were collected in early August 2008 in *Juncus balticus* around the edges of ponds near the station. Those found on 8 August were half grown, whereas those found in late August and September were adults. This is a common species in and around saltmarsh on the mainland (P. Catling, personal observation) but was rare on Sable Island in 2008. It was probably overlooked in earlier surveys.

*Neoconocephalus retusus* (Scudder) (Tettigoniidae), Round-tipped Cone-headed Grasshopper

A specimen was found dead in vegetation near the station during the late 1990s by Z. Lucas. This is the only Canadian record of a species normally reaching its northern limit in Connecticut. Since this is a large, conspicuous insect and no others have been seen, it is presumed not to be established on the island but rather to have been carried by strong storm winds from at least 1000 km to the south. The specimen is in the Nova Scotia Museum.

## Additional Notes

### Vascular Plants

Although *Senecio pseudo-arnica* (Asteraceae) was reported by St. John (1921), it was not found by Catling, Freedman and Lucas in 1981 (Catling et al. 1985) and was thought to be extirpated. In 2003, a large patch of > 100 plants was found in vegetated terrain along the north beach, and a second large patch was present in 2004. Since then, several smaller patch-

es have been found at other locations along the north beach. It is a conspicuous species, not easily overlooked, and is likely a re-colonization.

## Insects

*Catocala relictica* (Lepidoptera: Noctuidae) was known previously from a single record in 1978 (Wright 1989). A single specimen was found alive on a window at the Sable Island station between 2000 and 2003 (specimen at CNC). The larvae feed mainly on poplars (*Populus* spp.), birches (*Betula* spp.), and willows (*Salix* spp.), none of which occur on the island, and consequently it is likely that it was blown in (as suggested by Wright for the earlier record). Interestingly, there are several records for two other species of *Catocala* that feed on trees and shrubs not present on the island; these *Catocala* also must have flown in or been blown in. *Neoconocephalus retusus* was presumably also blown in (see above). These observations of extralimital occurrences, less easily interpreted on the mainland (where they could be a consequence of rarity or transport by automobiles, etc.), suggest the great distances that non-migratory insects can travel (possibly on storm fronts), and contribute to our understanding of biogeography.

*Agabus anthracinus* Mannerheim (Coleoptera: Dytiscidae) is known from Sable Island (Larson et al. 2000) but was not listed by Wright (1989).

*Omophron tessellatum* Say (Coleoptera: Carabidae) is still frequent on the island in low areas of periodically wet sand and on sandy edges of ponds but is active at night and particularly in rainy weather; this may help to explain why Wright (1989) did not encounter it.

*Phaedon viridis* F. E. Melsheimer (Coleoptera: Chrysomeloidae) was previously collected on the island but was identified as *Phaedon* sp. near *oviformis* LeConte (Howden 1970). This material was later revised to *P. viridis*. Two specimens collected in 2008 were identified by L. Lesage and placed in CNCI.

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# Common Loon, *Gavia immer*, Breeding Success in Relation to Lake pH and Lake Size Over 25 Years

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Alvo, Robert. 2009. Common Loon, *Gavia immer*, breeding success in relation to lake pH and lake size over 25 years. *Canadian Field-Naturalist* 123(2): 146–156.

I monitored Common Loon (*Gavia immer*) breeding success in relation to lake pH (range 4.0–8.5) between 1982 and 2007 on 38 single-pair lakes (5–88 ha) in the Sudbury, Ontario, area. No chicks fledged on lakes with pH < 4.4. Chicks fledged on lakes with slightly higher pH only if the lakes were relatively large. Acidic lakes became less acidic as sulphur dioxide emissions from the Sudbury smelters and sulphur deposition from other long-range sources decreased. Two lakes initially too acidic to support successful loon reproduction eventually had successful reproduction. One loon pair used two large acidic lakes (combined area 140 ha) connected by shallow rapids, and one of the adults made extremely long dives ( $\bar{x}$  = 99 s) while foraging for the chicks. One chick died on that lake after apparently ingesting a very large food item; the lack of smaller items was attributed to the lake's acidity. My results suggest that a shortage of food for chicks is the main reason why low pH reduces breeding success. I suggest that, for lakes without high levels of dissolved organic carbon (DOC), the critical pH for loon breeding success is approximately 4.3, and the suboptimal pH is approximately 4.4–6.0.

**Key Words:** Common Loon, *Gavia immer*, breeding success, forage, dive time, fledge, sulphur, pH, Sudbury, Ontario.

Great interest has been directed toward the welfare of the Common Loon (*Gavia immer*), mainly because it is an important symbol of “northern” wilderness. Human-related factors that are known to affect breeding success negatively include recreational lake use, water level fluctuations (Titus and VanDruff 1981), lead poisoning (Pokras and Chafel 1992), and mercury (Hg) toxicity (Barr 1986). Common Loons are dependent on their natal lake for all their food during the 11–13 weeks until they fledge.

In a three-year study conducted in the Sudbury, Ontario, area, Alvo et al. (1988) examined breeding success of loons and made observations of parents feeding their chicks on single-pair lakes (5–75 ha) with a wide pH range (4.0–8.5). We found then that loons tended to avoid breeding on small lakes and on acidic lakes; loons that attempted to breed were more successful in raising chicks on non-acidic lakes than on acidic lakes; loons were more successful in raising chicks on large and deep lakes than on small and shallow lakes; adult loons were more successful in capturing fish on non-acidic lakes than on acidic lakes; a pair of loons attempting to raise a small chick on a highly acidic, fishless lake, fed the chick benthic algae and possibly benthic invertebrates, but flew to other lakes to feed themselves; and the high level of brood mortalities on acidic lakes was probably the result of a shortage of suitable chick food. Other studies also found that loons avoid breeding on small lakes and acidic lakes (McNicol et al. 1995) and that they are more successful on non-acidic lakes than on acidic lakes (McNicol et al. 1987, 1995).

It is not clear from those studies whether there is a “critical pH” for loon breeding success, i.e., a pH

threshold below which loons cannot reproduce successfully, regardless of lake size. Nor is it clear whether there is a “suboptimal” pH range above the critical pH in which low loon productivity usually occurs. Obtaining higher precision regarding pH effects was the first objective of the current study. By monitoring breeding success and pH over many years, one may control for effects of predation on eggs and chicks, weather, and other factors affecting breeding success; loons nesting on a non-acidic lake may fail to raise chicks because the nest may be preyed upon or because of bad weather at a vulnerable time, but such a lake should have successful loons in some years. My second objective was to determine whether lake pH would change over the years and whether loon breeding success would change accordingly.

## Study Area

The study region around Sudbury, Ontario, had a dense concentration of lakes with a wide pH range (4.0–8.5), little human activity, and road access. The study lakes were 35–135 km from Sudbury's smelters, the major historical source of sulphur dioxide and metal emissions in the area (Keller et al. 2007). To minimize effects of high metal levels resulting from decades of deposition from the Sudbury smelters, I did not survey lakes closer than 35 km (Alvo 1985a). The original 84 study lakes encompassed four geographic areas, Areas 1–4 (Alvo 1985a; Alvo et al. 1988). The 38 lakes in the current study were a subset of 29 of those 84 lakes plus 9 acidic lakes added in 1988. The remaining 55 of the original 84 lakes were eliminated because they had no breeding pairs in 1982–1984, were no longer accessible, were too difficult to survey,



or were connected to other lakes. To reduce travel time, all lakes in Areas 1 and 2 were also eliminated. Thus the 38 lakes in the current study were located in Areas 3 and 4.

## Materials and Methods

### *pH Sampling*

I collected one water sample per year in most years with visits, in late August or in September. For the nine lakes added in 1988, pH was measured 5, 6, or 7 times between 1988 and 1998, depending on the lake, whereas in the other 29 lakes pH was measured 8, 9 or 10 times between 1982 and 1998, depending on the lake. In 2007, pH was measured on 24 of the 38 lakes.

In 1982, I took water samples from the original 84 lakes for analysis of acid buffering capacity (alkalinity titrations completed within 24 h of sampling) and pH near the lake centre by collecting a composite sample from the lake surface down to 1 m below the depth of the metalimnion at which the temperature decline was  $> 1^{\circ}\text{C}/\text{m}$ . I also measured the pH of the water surface for 24 lakes at the time of sampling to compare pH between the composite samples and surface samples. The greatest difference was 0.4 pH units. Keller and Pitblado (1986) found no significant difference in pH between surface and composite samples. I found no measurable difference between surface samples taken near the lake centre and those taken next to the shore. Therefore, starting in 1985, I took pH samples from the surface near the shore (always away from any effect of inflow streams). This saved considerable time when breeding success could be confirmed from the shore without having to use the canoe. Unless specified otherwise, lake pH refers to the lowest value obtained for the lake during the study. I consider this the most relevant pH because it is the most likely condition to cause negative effects on a lake's biota.

### *Loon Surveys*

Restricting the study to lakes that had a single pair facilitated finding nests, eliminated confusion in identifying different families on the same lake, matched chicks to the nests from which they had hatched, and restricted each loon family's food source to what was available in its own territory. In multi-pair lakes, fish and other prey for loon chicks can migrate into or out of one loon family's territory from the territories of neighbouring loons and from neutral areas.

I surveyed the 38 lakes for loons generally only once each year, in September, in 12 seasons from 1982 to 1998 (1982–1986, 1988–1990, 1993, 1996–1998). In the early years, I often visited some lakes more than once, mostly to observe parents foraging for their chicks, to take water samples, or to sample other biota. I also surveyed six of the lakes for loons in 2002, and four in 2007. Whenever a scan from the shoreline using binoculars and/or a spotting scope did not reveal the presence of one or two chicks after about 10 min, I canoed around the entire shoreline, including islands

and marshy bays, to find the nest (if present). Examination of the extent of fading of the eggshells found in a nest allowed me to determine whether the nesting attempt had occurred that year or in a previous year (Alvo and Prior 1985). When I found one or two intact egg membrane sacs in the nest, I concluded that hatching had occurred, although sacs are present in only approximately half of all nests with hatching (Alvo 1985b). My visits were made when chicks were generally more than 6 weeks old, but usually much closer to fledging. Even though chicks do not fledge until 11–13 weeks after hatching (McIntyre 1975), I considered loon pairs (or lakes) to be "successful" if I observed one or two large chicks.

### *Chick food and parents foraging for their chicks*

I systematically watched parents foraging for chicks on two acidic lakes. I watched one loon family on Lake 26 (pH 4.2) for 31 h on 27–29 July 1985 and I watched another family on Lake 90 (pH 4.4) for 4 h on 28 September 1996. Those lakes were rarely visited by humans, and most observations on them were made from shore using  $7 \times 35$  binoculars and a 15–25 $\times$  spotting scope. On both lakes, the loons became visibly and vocally agitated when I attempted to approach closer than 600–800 m. That contrasted sharply with loons in Killarney Provincial Park where, with heavy canoe traffic, the loons had become remarkably tolerant of humans, allowing approach to within 5 m without alarm.

## Results

### *Changes in Lake pH*

The pH of all nine lakes with minimum pH 4.0–4.9 during the period 1982–1998 increased above their 1982–1998 ranges by 2007. Increases ranged from 0.6 to 1.5 pH units (e.g., Lake 88: 4.0 in 1989 and 5.5 in 2007). All four lakes with pH 5.0–5.9 during the period 1982–1998 were still within their 1982–1998 ranges in 2007. Of seven lakes with pH 6.0–6.9 in 1982–1998, four were still within their 1982–1998 ranges in 2007 and three had fallen. Finally, of four lakes with pH 7.0–7.9 in 1982–1998, one was still within its 1982–1998 range in 2007 and the other three had fallen. The greatest decrease (1.9 pH units, 7.7–5.8) occurred on Lake 65. Of the generally high-alkalinity lakes in Area 4 that I retained for the current study (Alvo et al. 1988), Lake 65 had the lowest alkalinity (217  $\mu\text{eq}/\text{L}$ , compared to a maximum of 1806  $\mu\text{eq}/\text{L}$ ), which may explain the large pH decrease. The lowest alkalinity measurement obtained was  $-73 \mu\text{eq}/\text{L}$  (pH 4.0, Lake 82). Thus, the most acidic lakes showed a considerable increase in pH over the 25 years, whereas the high-pH lakes showed a considerable decrease. The intermediate lakes showed no obvious change.

### *Lake Size*

Of the original 84 lakes I surveyed in 1982 (Alvo 1985b) and the 9 added in 1988, the smallest of the

TABLE 1. Lake types according to pH and loon breeding activity.

Lake type	Description	Minimum pH	Mean lake size (ha) (range)	Lake	Number of lakes
I	Part of the same breeding territory as another lake	4.4–4.5	88 + 52 = 140	91 (same territory as Lake 90)	1
II	Abandoned — No breeding attempts after 1986 ( $\geq 1$ in 1986 or earlier)	4.7–7.2	10 (5–22)	2, 4, 16, 27, 53, 57, 58	7
III	Acidic without breeding attempts	4.0–4.2	18 (17–19)	88, 92, 93	3
IV	Acidic with $\geq 1$ breeding attempt but no proof of hatching	4.5–5.2	10, 31	85, 87	2
V	Inconsistent breeding success (<50% successful years)	5.8–7.4	25 (14–56)	10, 11, 12, 30, 54, 56, 63, 70, 71, 73	10
VI	Acidic with proof of hatching	4.0–4.7	49 (25–75)	15, 26, 86, 89, 90	5
VII	Non-acidic with consistent breeding success ( $\geq 50\%$ successful years)	5.8–7.7	24 (10–50)	1, 17, 19, 48, 49, 64, 65, 67, 69, 84	10
Total		4.0–7.7			38

93 lakes on which I observed any loons was 4 ha, although the smallest lake surveyed was 2 ha. The smallest lake with a nest (Lake 58, pH = 6.7) was 5 ha. However, the smallest successful lake was 8 ha (Lake 53, pH 7.2). It contained six fish species (my unpublished data from minnow trapping combined with data from the Ontario Ministry of Natural Resources). Ten minnow traps set overnight yielded > 2000 fish.

#### *Breeding Success on the 38 Study Lakes*

I classified the 38 lakes into seven types according to pH and the breeding activity of loons (Table 1) in order to identify the two lake types that should best address the issue of brood survival with respect to pH: Type VI — acidic lakes (pH 4.0–4.7) with hatching, and Type VII — non-acidic lakes (pH 5.8–7.7) with consistent breeding success ( $\geq 50\%$  successful years).

Type I. Part of the same breeding territory as another lake (pH 4.4–4.5). Lake 91 (pH 4.5, 88 ha) was used by the same pair that used Lake 90 (pH 4.4, 52 ha).

Type II. Abandoned — No breeding attempts after 1986 ( $\geq 1$  in 1986 or earlier). These seven lakes had  $\geq 1$  breeding attempts from 1982 to 1986, but none afterward. Four of them had successful breeding in  $\geq 1$  years. These lakes were small ( $\bar{x}$  = 10 ha, range 5–22 ha) and had a wide pH range (4.7–7.2).

Type III. Acidic (pH 4.0–4.2) without breeding attempts. No breeding attempts were detected on these three lakes, despite the fact that each was surveyed in four to seven years. Lake size was 17–19 ha.

Type IV. Acidic (pH 4.5–5.2) with  $\geq 1$  breeding attempts, but no proof of hatching. Two acidic lakes (Lake 85: pH 4.5, 10 ha; Lake 87: pH 5.2, 31 ha) had loons attempting to breed at least once, but no chicks were ever observed and nest remains were such that hatching could not be proven.

Type V. Inconsistent breeding success (< 50% successful years). These 10 lakes had inconsistent breed-

ing success, being successful in < 50% of the years with surveys. pH on these lakes was 5.8–7.4, and lake size was 14–56 ha.

Type VI. Acidic (pH 4.0–4.7) with proof of hatching. Lake 15 (pH 4.5, 25 ha) had consistent non-successful breeding (nests found in all seven years with data from 1982 to 1989, including three years with known hatching and subsequent brood mortality) followed by fairly regular successful breeding from 1990 to 2002 (nests found in each of six years, with one chick fledging in each of three years). This change from no breeding success to success occurred as pH increased from 4.5–5.1 in 1982–1989 to 4.9–5.3 in 1990–1998. However, a fourth brood mortality occurred in 1993, leaving open the possibility that lakes where pH is recovering may go through a period of years when breeding success is possible in only some years.

In mid-August 1984, I set 10 baited minnow traps covering approximately 22 h in Lake 15 (pH 4.5) and in three lakes with higher pH (6.1–7.4) located within 4.5 km of Lake 15. I caught nine Yellow Perch (*Perca flavescens*) 10–12 cm long and one tadpole in Lake 15. The three healthier lakes each yielded 4–23 perch (1–5 cm) and 2–21 crayfish (2–7 cm), but no tadpoles. I documented brood mortalities on Lake 15 in 1982, 1983, and 1984, whereas the loons on the other three lakes all raised two chicks in 1984. These modest data may suggest that Lake 15 might not yet have had enough of the appropriate sizes (e.g., fish 1–5 cm long) and types (e.g., crayfish) of food normally fed to chicks; food requirements change drastically during the pre-fledging period (Alvo and Berrill 1992).

Lake 26 was very acidic (pH 4.2) and very large (75 ha). Breeding attempts occurred in 10 of 12 years from 1982 to 2007; this period included four years when I documented brood mortalities. I never observed successful breeding on this lake.



The loons on Lake 86 (pH 4.7, 44 ha) were successful regularly from 1988 to 1998, nesting in six of seven years and raising chicks in four of those years.

Lake 89 (pH 4.0, 50 ha) had fairly consistent non-successful breeding followed by success during a period of increasing pH. No loons or nests were observed in 1988 or 1989. In 1993, I found a nest with no egg remains. Loons nested in 1996, but the only eggshells found were ones laid in 1995. In 1998, there was a nest with eggshells, but still no chicks. Finally, in the fifth year with a breeding attempt, I saw one parent with a large chick on 6 September 2007. After canoeing several hundred metres of shoreline and searching through the very clear water, I saw one dead crayfish, in contrast to previous years, when similar searches revealed no crayfish. I have not seen fish in this lake, and have found only an individual amphibian over the years, a Green Frog (*Lithobates* [formerly *Rana*] *clamitans*) in 1996. From 1988 to 1998, the pH on this large lake varied from 4.0 to 4.5, followed by an increase to 5.2 by 2007. Unfortunately, I had set no minnow traps in this lake.

The loons on Lake 90 (52 ha) raised chicks in four of seven years during 1988–1998, when the pH was 4.4–4.9.

Type VII. Non-acidic (pH 5.8–7.7) with consistent breeding success ( $\geq 50\%$  successful years). Ten lakes with pH 5.8–7.7 had consistently successful breeding during the course of the study, defined here as  $\geq 1$  chicks produced in at least half of the years with data. The size of the lakes averaged 24 ha (range 10–50). Of these 10 lakes, the average size of the 6 lakes with pH 6.5–7.7 was smaller ( $\bar{x} = 21$  ha) than the average size of the 4 lakes with pH 5.8–6.2 ( $\bar{x} = 29$  ha).

The highest breeding success rate observed over the long term (measured as the number of years with a successful loon pair divided by the number of years with observations) among these 10 lakes was 67%, this being shared by three lakes (Lake 1, 32 ha; Lake 64, 36 ha; and Lake 67, 20 ha). The longest string of successful years, five, was observed on Lake 64 (pH 7.3, 36 ha) from 1982 through 1986.

#### *Chick Food and Parents Foraging for Chicks on Two Differing Acidic Lakes*

Lake 26. The loon family foraged in only a very small portion of the lake (200 m  $\times$  200 m), where the only available food—filamentous algae and possibly small aquatic insects in the algal mat—was ubiquitous (Table 2). At times I could see something long that fit the description of filamentous algae hanging from the parent's bill as it approached the chick, which I estimated to be one week old. Large concentrations of adult damselflies (Zygoptera) were noted along the shores of the lake in 1996, indicating that the lake benthos likely harboured insect larvae. Also, whirligig beetles (Gyrinidae) formed large concentrations on the lake surface, and I could see the chick feeding on them. The chick spent considerable time foraging for itself.

I set 10 minnow traps overnight in Lake 26 in 1984, but caught no vertebrates or invertebrates (Table 2).

Neither parent would go off on its own to feed in a different part of the lake. Instead, they would fly from the lake individually, and return several hours later. This, and the fact that I never observed them foraging for themselves on Lake 26, suggested that they foraged for themselves on other lakes.

Successful dive times of parents foraging for the chick on Lake 26 averaged 19.3 s (SD = 14.7,  $n = 135$ ). They fed the chick after 96% of the dives.

Lake 90. Unlike the loon family on Lake 26, the one on Lake 90 foraged throughout the lake, as do families on healthy lakes, regardless of chick age (Alvo and Berrill 1992). Dive times of a parent foraging for two large chicks in Lake 90 on 28 September 1996 were extremely long ( $\bar{x} = 98.7$  s, SD = 25.1,  $n = 41$ , range 31–159 s). One of the two chicks died after being found moribund with a bulge in its neck that we found to contain Yellow Perch, dragonfly larvae, crayfish, and whirligig beetles (see Discussion), indicating that these food types were available in the lake (Table 2).

In 1993, I watched an adult lead two large chicks through some shallow rapids (approximately 0.5 m deep) (they all dove through) from Lake 90, itself a large lake (52 ha), to Lake 91 (88 ha). The chicks begged almost continuously for 30 min, the sound carrying up to 200 m—this was something I had never observed on other lakes. I had already suspected from observations made in previous years that one pair was using both lakes. I observed Yellow Perch (approximately 4 cm long) in both lakes in 1988.

## Discussion

### *Changes in Lake pH*

Keller et al. (2007) monitored 44 acidic lakes in the Sudbury area from 1981 to 2004, and found that the number of lakes with pH < 5.0 decreased from 28 to 6. Increases in pH in the Sudbury area lakes followed substantial reductions in sulphur emissions from the smelters in the late 1970s (Keller et al. 1992a). Biological improvement followed (Keller et al. 1992b). In the early 1980s, some lakes in the Sudbury area had abnormally high pH for the region; pH has since been decreasing to normal levels, so the decrease in pH in my lakes with high pH is not surprising (Bill Keller, personal communication, 2008).

### *What do the Seven Lake Groups Tell Us about Brood Survival in Relation to pH and Lake Size?*

Type I. Part of the same breeding territory as another lake (pH 4.4–4.5). Lake 91 was used by the same pair as Lake 90. I suggest that the very large combined lake area (140 ha) was necessitated by the shortage of chick food related to the low pH.

Type II. Abandoned — No breeding attempts after 1986 ( $\geq 1$  attempts in 1986 or earlier). These lakes were suboptimal habitat for breeding loons. The lakes' small size was probably a major factor. Other factors

TABLE 2. Breeding success on Lake 26 vs. Lake 90 in relation to pH, lake size, and available chick food.

Lake parameter	Lake 26 (Marjorie Lake)	Lake 90 (Silvester Lake)
Minimum pH	4.2	4.4
Lake size (ha)	75	52; or, 140 when combined with Lake 91 (Wolf Lake - 88)
Fish	No (Conlon et al. 1992; McNicol et al. 1996a; Alvo, unpublished data)	Yes — Yellow Perch found in dead loon chick's esophagus, and seen in shallow water
Crayfish	Probably not — none caught in minnow traps (Alvo, unpublished data); cooked rice in shallow water present after 2 weeks	Yes — <i>Cambarus robustus</i> found in dead loon chick's esophagus
Dragonfly larvae	Unknown — not sampled	Yes — <i>Somatochlora cingulata</i> and <i>Aeschna</i> sp. found in dead loon chick's esophagus
Whirligig beetles	Yes — groups seen on lake surface	Yes — Groups seen on lake surface, <i>Dineutus nigrior</i> found in dead loon chick's esophagus
Benthic filamentous algae	Yes	Yes

that may have contributed to abandonment were water level changes, shallow lake depth, low water clarity, human disturbance, and death of breeding pairs combined with an insufficient number of replacement individuals.

Type III. Acidic (pH 4.0–4.2) without breeding attempts. These three lakes should have been large enough to support one loon pair each. I attribute the lack of breeding attempts to the very low pH of the lakes (Alvo et al. 1988).

Type IV. Acidic (pH 4.5–5.2) with  $\geq 1$  breeding attempts, but no proof of hatching. These two acidic lakes (pH 4.5–5.2) had loons that attempted to breed at least once, but no chicks were ever observed and nest remains were such that hatching could not be proven. This result simply confirms that breeding attempts may occur on lakes within this pH range, but tells us nothing about brood viability.

Type V — Inconsistent breeding success (< 50% successful years). These 10 lakes tell us little that we do not already know regarding brood survival in relation to pH and lake size.

Type VI. Acidic (pH 4.0–4.7) with proof of hatching. An examination of the five Type VI lakes suggests that successful breeding was not possible at pH 4.2 (Lake 26, 75 ha), despite breeding attempts in all but one year. Successful breeding became possible at pH 4.4, but only on very large lakes, where one family could compensate for the low food density by using a very large territory (e.g., Lakes 90 and 91 combined, 140 ha). Loons bred successfully on large Lake 86 (pH 4.7, 44 ha). On Lake 15 (25 ha), loons could not raise chicks at pH 4.5–4.9, but were successful at pH 5.1. Lake 89 had no success at pH 4.0–4.5, but the loons finally raised a chick at pH 5.2. All these results suggest a critical pH of approximately 4.3.

Type VII. Non-acidic (pH 5.8–7.7) with consistent breeding success ( $\geq 50\%$  successful years). The impor-

tance of lake size is again illustrated by the fact that, of the 10 lakes with consistently successful breeding during the course of the study, those lakes with low pH (5.8–6.2) had a larger average size than those with high pH (6.5–7.7). A negative effect on low productivity may occur below approximately pH 6.0. My results show that some single-pair lakes supported a family of loons five years in a row.

#### Lake Size

Immediately above the critical pH level of 4.3, loons on lakes with pH 4.4–4.7 were successful only on large lakes (> 25 ha). Also, of the two lakes whose pH increased enough to support reproduction (Lakes 15 and 89), the more acidic of the two (Lake 89, pH 4.0) was considerably larger (50 ha) than the three non-acidic lakes with the highest success (67%) over the study (20–36 ha). On single-pair lakes the availability of food for chicks, whatever the prey base, should increase with lake size at a given lake trophic level. For example, loons breeding on oligotrophic (total phosphorus (TP)  $\leq 10 \mu\text{g/L}$ , Vollenweider and Kerekes 1980\*) lakes in Nova Scotia raised chicks only on lakes > 40 ha (Kerekes et al. 1994), whereas loons breeding on ultra-oligotrophic (TP  $\leq 4 \mu\text{g/L}$ ) lakes in Newfoundland with correspondingly low fish production required > 100 ha to support one chick to fledging (Kerekes et al. 2000). However, fertilization of a 26-ha lake in Newfoundland, which without fertilization would be much too small to support reproduction, rendered it capable of supporting one chick until the last survey in September five years in a row. In the first year when fertilization ceased, one chick hatched but had disappeared by September. Larger control lakes had sporadic nesting, but no chicks fledged on them (Knoechel et al. 1999). In contrast, loons on a very small (2.7 ha) mesotrophic (TP =  $26.2 \mu\text{g/L}$ ) lake in north-central Alberta raised a chick (Gingras



and Paszkowski 1999). Total phosphorus in 20 of my study lakes in Area 3 was 2–12  $\mu\text{g/L}$  (McNicol et al. 1996a), but it was likely higher in many of the lakes in Area 4, given the higher pH and alkalinity.

#### *Chick Food and Parents Foraging for Chicks on Two Acidic Lakes*

Lake 26. In comparison with parents foraging on healthy lakes for chicks 4–15 days old ( $\bar{x}$  = 21.8 s, SD = 13.3,  $n$  = 160) (adapted from Alvo and Berrill 1992), adult successful dive times while foraging for the estimated one-week-old chick on Lake 26 were not significantly shorter ( $\bar{x}$  = 19.3 s, SD = 14.7,  $n$  = 135) ( $t$  = 1.53,  $df$  = 293,  $P$  > 0.05), but the foraging success rate was significantly higher (96% vs. 87%;  $\chi^2$  = 9.1,  $df$  = 1,  $P$  < 0.005). This, combined with the fact that the loon family did not forage normally by following the shoreline and circling the lake, or at least a bay, suggests that the parents were foraging on ubiquitous items that were easy to secure, such as algae and invertebrates in the algal mat. (On healthy lakes, some small fish are fed to chicks in this age group [Alvo and Berrill 1992], and this may account for the lower success rate.) Because Lake 26 had no larger mobile prey, such as fish, the loons presumably had no reason to follow the lake perimeter. The fact that the lake was fishless was confirmed by the combination of my trapping results and those of Conlon et al. (1992) and McNicol et al. (1996a).

Lake 90. Lake 90, on the other hand, had fish, crayfish, and dragonfly nymphs (Table 2). Dive times of the parent averaged more than twice as long as those of a parent foraging for a large chick on healthy Lake 69 on 14 September 1983 ( $\bar{x}$  = 38.8 s, SD = 10.6,  $n$  = 94, range 8–68 s) ( $t$  = 19.3,  $df$  = 133,  $P$  < 0.005) and more than twice as long as dive times of lone adults foraging for themselves on five healthy (pH 7.0–8.5) lakes ( $\bar{x}$  = 45.8 s, SD = 18.1,  $n$  = 317, range 3–88 s;  $t$  = 16.7,  $df$  = 356,  $P$  < 0.005) (adapted from Alvo and Berrill 1992). I selected these data to control for chick age, because the mean dive time of parents foraging for chicks increases during the pre-fledging period as the food types and sizes of food fed to the chicks change (Alvo and Berrill 1992). When a parent is foraging for chicks, the mean successful dive times (dives after which the parent surfaces with food) tend to be shorter than the mean unsuccessful dive times (dives after which parents surface without food) (Alvo and Berrill 1992). For Lake 90, I combined unsuccessful dives and successful dives because I could not always distinguish them due to the great distance between the loons and myself. There are no reports in the literature of such a string of long dives by loons.

Most of the mean dive times of adults of the five loon species reported in the literature are between 30 and 50 s. Nocera and Burgess (2002) reported adult dive times up to 124 s, with means for different situations varying from 30 to 50 s. However, they did not report whether the longest times tended to occur in

relation to low lake pH and/or low food densities. Other reports of very long dives exist (3–15 min) (Olson and Marshall 1952; Madsen 1957), but seem exceptional or doubtful, whereas the ones on Lake 90 occurred in sequence.

I suggest that my observations on Lake 90 involved a parent loon diving in earnest because the density of appropriate food was low as a result of the lake's acidity. Had there been high levels of mercury (Hg) in the adult loon on Lake 90, this should have impeded its ability to dive for such a long time, given that Hg is a neurotoxin associated with difficulty in swimming in loons (Driscoll et al. 2007a). I see merit in the suggestion by Nocera and Burgess (2002) that loons typically forage at depths less than their aerobic diving limit and modify their dive times and pause times based on the demands in place at the time (e.g., increased vigilance for territoriality or chick protection, increased need for food for chicks). Parker (1985, 1988) also found loons compensating for reduced food, at pH 4.7–5.1, by spending a longer time feeding their chicks, relying heavily on food types that were still available but possibly not optimal, and, in rare cases, ferrying in fish from other lakes.

An autopsy of the chick that died with a bulge in its throat led us to conclude (in Alvo and Campbell 2000) that it "may have swallowed a large fish that punctured the esophagus on its way to the proventriculus, causing peristalsis to cease. Food subsequently swallowed could not move beyond the esophagus, thus forming the bolus. The loon may have swallowed the large fish because food of suitable size for a bird of that size was in short supply due to the lake's acidity." Lead-poisoned loons have shown evidence upon necropsy that digestion had ceased in the esophagus before death, with a bolus of crayfish, or simply a number of crayfish, being found in the neck bulge (Locke et al. 1982; Alvo and Campbell 2000). In summary, the results of foraging observations on Lakes 26 and 90, with pH 4.2 and 4.4, respectively, and with a widely differing food resource, also suggest a critical pH near 4.3.

#### *Loon Chick Food*

Loons eat an immense variety of foods, yet they are often mistakenly described as "obligate piscivores" (e.g., Evers et al. 2007; Kenow et al. 2007). Vegetation is eaten by both chicks (Alvo and Berrill 1992) and adults (McIntyre 1988). Possibly the only freshwater animal larger than 1 cm long not recorded as being eaten by loons is the sponge (Porifera). Ducklings are also taken (Brooks 1941). The degree to which loons apparently favour fish has not been well studied. Difficulties include the fact that adult loons usually swallow their prey under water, where it cannot be seen by an observer; the fact that gut contents tend to reveal hard-bodied animals and under-represent soft-bodied animals and vegetation; and the fact that food types available on freshwater lakes, where

loons breed, and on their marine wintering areas differ considerably.

Red-throated Loons (*Gavia stellata*) and Pacific Loons (*G. pacifica*) sometimes breed on fishless pools (Snyder 1957; McNicholl 1973). The former regularly ferries food into the nesting pond or lake, one fish at a time (Bergman and Derksen 1977), and Pacific and Arctic loons (*G. arctica*) may also do so (Andres 1993). Common Loons do this only rarely. However, Common Loon chicks sometimes move short distances overland to take advantage of other food resources (McIntyre 1988).

I suggest that the period from hatching to departure from the natal lake may be the most critical time in a Common Loon's life for food availability, because chicks are largely restricted to food that they or their parents can find on the natal lake. Successful breeding has been shown to occur on fishless lakes that have other food types (Munro 1945; Gingras and Paszkowski 2006). In the latter study, leeches, especially *Nepheleopsis obscura*, were the most common invertebrates fed to chicks.

In Area 3, leeches were absent at pH < 4.9 (Bendell and McNicol 1991), snails were absent at pH < 5.0 (Bendell and McNicol 1993), and crayfish were absent at pH < 5.2 (McNicol et al. 1996b). Amphibian larvae were absent below pH 4.4 (McNicol et al. 1996b). On the most acidic lakes in my study (e.g., Lake 26, pH 4.2) the water was extremely clear, filamentous algae generally covered the bottom, which likely contained some aquatic invertebrates such as dragonfly larvae, and there were no fish.

Common Loon chicks eat numerous kinds of invertebrates (Barr 1996). The chicks are omnivorous at first, gradually shifting to a diet of mostly fish (Alvo and Berrill 1992), as in Arctic and Pacific loon chicks (Lehtonen 1970; Petersen 1989).

#### *pH Thresholds for Loon Breeding Success*

My results suggest that breeding success was highly unlikely, if not impossible, at pH  $\leq$  4.3, regardless of lake size, in the Sudbury area. Such lakes were generally, if not always, fishless (Kretser et al. 1989\*), and lacked crayfish (McNicol et al. 1996b), leeches (Bendell and McNicol 1991), snails (Bendell and McNicol 1993), and amphibian larvae (McNicol et al. 1996b). I never saw signs of any of these organisms in the 13 lakes with pH 4.0–4.3, despite the high clarity of their waters (maximum Secchi depth 18.5 m, Lake 82), and adult amphibians were rare. Loon parents likely had to visit other lakes to feed themselves (e.g., Lake 26).

A critical pH of 4.3 likely does not apply when the dissolved organic carbon content (DOC) is very high, for example in Kejimikujik National Park in Nova Scotia. DOC complexes and partially detoxifies metals such as aluminium (Kerekes and Freedman 1989). In the Adirondack Mountains of New York state, Yellow Perch did not occur at pH < 4.5 (Kretser et al. 1989\*), but at Kejimikujik they occurred at pH 4.1 (Kerekes

and Freedman 1989). DOC in my 20 lakes with data varied from 0.9 to 7.1 mg/L (McNicol et al. 1996a). In Kejimikujik lakes, however, it varied from 3 to 20 mg/L (J. Kerekes, personal communication, 2008).

The suboptimal pH extends from 4.3 to some upper limit. Based on extensive work over almost four decades, Environment Canada (2004) concluded, "pH 6.0 is a key threshold for the sustenance of fish and other aquatic biota." My results also point to a pH level of approximately 6.0 as an important threshold specifically for Common Loons, which depend on the fish and other biota mentioned above to reproduce, for the following five reasons.

1. Of the 10 lakes with consistently successful breeding success, the 6 with pH 6.5–7.7 had a smaller average size than the four with pH 5.8–6.2.
2. Although Lake 15 became capable of supporting reproduction once its pH had risen to 4.9–5.3 in 1990–1998, a subsequent case of brood mortality suggested that it might not have become capable of supporting reproduction year after year until it reached a higher pH. In contrast, lakes with pH > 6.0 may have broods five or seven years in a row.
3. Lake 89 supported a large chick once the pH of the lake had risen from a high of 4.5 in 1988–1998 to 5.2 in 2007. A similar smaller lake might not have been able to support a large chick.
4. Lakes 86 and 90 (pH 4.7 and 4.4, respectively) supported reproduction consistently, but were quite large (44 and 140 ha, respectively).
5. For chicks that had reached an age when  $\geq$  90% of the food items fed to them consisted of fish, foraging success rates of their parents foraging on two lakes with low pH (Lake 4, pH 5.8; Lake 11, pH 6.1) were significantly lower (10%,  $n = 216$ ) than those on two lakes with high pH (23%,  $n = 170$ ; Lake 53, pH 7.2 and Lake 69, pH 7.0) (results adapted from Alvo et al. 1988).

The limit of any suboptimal range that is farther from the critical level is always more difficult to determine because, by definition, it is close to the level of no effect. Nevertheless, given the above five observations, a suboptimal pH of 6.0 for successful breeding in Common Loons seems reasonable.

My results from Lakes 15 and 89 demonstrate that some acidic lakes that seem to be incapable of supporting loon reproduction can eventually become capable of doing so when sulphur dioxide emissions are reduced enough so that biological recovery can occur. An improvement in the quality of lake habitat for loons in the Sudbury area is indicated by the increase that occurred in breeding fish-eating birds, including Common Loons, when pH was increasing from the mid-1980s through the 1990s (McNicol 2002).

Gingras and Paskowski (2006) and Burgess and Meyer (2007) suggested that mercury (Hg) toxicity



may have been a confounding factor in the brood mortalities observed by Alvo et al. (1988). Eastern North America receives Hg through atmospheric deposition that is magnified millions of times as it rises up the aquatic food chain to loons (Driscoll et al. 2007b). Elevated Hg levels in loons or their prey have been related to reductions in egg-laying, in nest fidelity, in territorial fidelity, in time spent back-riding by chicks, and in productivity; elevated corticosterone levels; lethargy; compromised immune systems; and asymmetry in plumage development (Barr 1986; Nocera and Taylor 1998; Burgess et al. 2005; Burgess and Meyer 2007; Evers et al. 2007; Kenow et al. 2007). Hg levels in loons and their prey are often related negatively to lake pH (Meyer et al. 1995, 1998). Merrill et al. (2005) measured both food intake and Hg exposure in wild loon chicks and concluded that a decrease in prey biomass was a more likely cause of low survival than elevated Hg, but the results were inconclusive.

Without having Hg values in loons or their prey for my study lakes, it is difficult to determine the impact that Hg might have had on breeding success in my study lakes. The metal smelters at Sudbury release considerable amounts of selenium, which protects aquatic organisms against Hg toxicity (Belzile et al. 2006; Yang et al. 2008). Nevertheless, in some Sudbury lakes, Hg levels high enough to affect loon productivity adversely have been found in fish of a size range preferred as prey by adult loons and/or chicks (Scheuhammer and Blancher 1994; Chen et al. 2001). This indicates that loon breeding success may be affected negatively on some Sudbury lakes. However, the fact that loon chicks hatched consistently on acidic lakes 15, 26, 86, and 90 suggests that decreased egg-laying, decreased nest fidelity, and aberrant incubation behaviour (Barr 1986; Evers et al. 2007) were not important on these lakes. I did not observe lethargy in adult loons (Evers et al. 2007) on any of my lakes, despite many hours of observations of parents feeding their young on non-acidic lakes (Alvo and Berrill 1992) and on acidic lakes (lakes 26 and 90). Nor did I notice an abnormally high number of unhatched eggs or decreased back-riding by chicks on acidic lakes. Had the foraging parent's Hg levels on Lake 90 been high, I would have expected its dive times to be shorter than normal rather than longer, because Olsen et al. (2000) found higher diving rates in loons with high blood Hg, and higher diving rates imply shorter dive times. Finally, there is no reason to suspect that the importance of large lake size for successful loon reproduction resulted from lower Hg on larger lakes.

Copper and nickel reached very high levels in the lakes within 20–30 km of Sudbury (Keller et al. 2007). Their levels in the Sudbury lakes as measured in 1981 and 1989 decreased drastically with distance from the smelters, reaching levels at 30 km (Keller et al. 1992a) that were lower than the Ontario Ministry of the Environment objectives for the protection of aquatic life (Bill Keller, personal communication, 2008). Levels

of copper (2–4 ug/L) and nickel (2–18 ug/L) in 20 of my Area 3 lakes with data were similarly low (McNicol et al. 1996a), and the levels of lead, cadmium, copper, and nickel found in aquatic invertebrates in Area 3 (Scheuhammer et al. 1997) were considerably lower than levels known to have toxic effects in their consumers. Metal emissions in Sudbury have been reduced by about 90% in recent decades (Keller et al. 2007). In conclusion, these metals do not seem to have played an important role in decreasing loon breeding success in Sudbury.

Loon chick mortalities on my lakes with low pH may have been partly due to reduced growth after hatching, as observed in Tree Swallows (*Tachycineta bicolor*) nesting next to wetlands with low pH in Area 3 (Blancher and McNicol 1988). Blancher and McNicol (1991) suggested that swallow chicks might not have obtained enough calcium in their diets because of a reduction in prey that is normally rich in calcium (Scheuhammer et al. 1997; Keller et al. 2001). Another potential mechanism for reduced breeding success on lakes with low pH could involve the decrease in eggshell thickness (Pollentier et al. 2007).

Why did loons attempt to breed on Lake 26 after so many years with unsuccessful breeding attempts? Loons may live 25–30 years or longer (Nilsson 1977; McIntyre 1988) and tend to return to the same lakes year after year, especially after raising chicks (Piper et al. 1997). Consider the following scenario: a loon pair breeding successfully on Lake 26, when fish are starting to die in the 1950s, finds that the lake has insufficient food for the chicks. They continue to nest each year despite brood losses because of their strong affinity to the lake. Eventually, the male dies and the female finds another male. Later the female dies and the second male finds another female. The new pair continues to use the same lake, even though neither of the two birds was a member of the original pair. This “tradition” continues until both birds die at the same time, thus losing the “memory” of that breeding lake.

Even now that the long-time myth of loons pairing for life has been shattered by the discovery that territorial switching occurs commonly (Evers et al. 1996\*) and that male loons kill others to usurp their territories (Walcott 2010), loon traditions can continue, and are perhaps enhanced, when more than two loons use a lake over several years, as is now known to occur regularly (Piper et al. 1997).

Conversely, the attractiveness of Lake 26 to loons may simply be a result of its large size. It is possible that each year the unsuccessful pair abandoned the lake and was replaced by another pair the following year. Breeding densities of loons near Area 3 are quite high, and increased immigration into the Sudbury area might be occurring (D. McNicol, personal communication, 2008).

Our (Alvo et al. 1988) statement that, “given the relatively small number of such [heavily acidified] lakes in North America, it is doubtful that the popula-

tion of Common Loons on this continent is currently being reduced significantly by lake acidification," was too optimistic. Of about 700 000 lakes in the temperate areas of eastern Canada alone (Schindler 1998), 500 000–600 000 that were historically capable of having a pH > 6.0 will have pH < 6 under current conditions of acid deposition (Environment Canada 2004). Much greater sulphur dioxide emission reductions than those required by legislation in Canada and the U.S. will be needed to promote chemical and biological recovery (Jeffries et al. 2003). If the proportion of lakes with pH < 6.0 increases, I predict that loon territory sizes will grow due to the need for more chick food, the number of available territories will decline as a result, and loon productivity in turn will decline. However, if significant sulphur dioxide emission reductions occur, loon territory sizes should decrease, the number of available territories should increase, and loon productivity in turn should increase.

Common Loon pair counts from 1990 to 2003 increased significantly in Ontario, Quebec, and Newfoundland, and these results are encouraging. However, little information exists on loon breeding success in eastern Canada (Environment Canada 2004).

Evidence of natural recovery of aquatic communities from acidification is rare, and Sudbury is an excellent example (Keller et al. 2002). Lakes in the Sudbury area provide one of the best examples in the world of the environmental benefits of sulphur emission controls (Keller et al. 2007). The Sudbury lakes are an ongoing experiment that can never be repeated, because any similar acidification situation from now on will be complicated by global warming, increased ultraviolet radiation (Schindler 2001; Keller et al. 2007), mercury (Driscoll et al. 2007a), and exotic and native invasive species. If the main mechanism behind the relationship between pH and loon breeding success is indeed reduced food of the appropriate types at each stage of growth of pre-fledged chicks on low pH lakes, then my results should apply to lakes in other situations, regardless of the cause of the altered state of their biota. Reduced breeding success will begin earlier than the time at which the ecological equivalent of the critical pH is reached, probably when the ecological equivalent of the suboptimal pH is reached.

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# Declines of Bighorn Sheep, *Ovis canadensis*, on Deteriorating Winter Range in Jasper National Park, Alberta, 1981–2010

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Dekker, Dick. 2009. Declines of Bighorn Sheep, *Ovis canadensis*, on deteriorating winter range in Jasper National Park, Alberta, 1981–2010. *Canadian Field-Naturalist* 123(2): 157–164.

Bighorn Sheep (*Ovis canadensis*) wintering in the lower Athabasca River valley of Jasper National Park, Alberta, were monitored from 1981 to 2010 by recording maximum band sizes per annum on two traditional but separate sheep ranges. In study area #1, the ram band declined significantly from a 20-year mean of 18 in the period 1981–2001 to a 5-year mean of 11 in the period 2001–2006, with a slight recovery in 2006–2010. Ewes in area #1 dwindled from a mean of 20 in the period 1981–1995 to zero in the period 1995–2010. In area #2, the ewe band dropped significantly from a mean of 40 in the period 1981–2001 to 24 in the period 2001–2010. The declines in area #1 coincided with an invasion of Russian Thistle (*Salsola kali*). Range conditions in area #2 deteriorated following four years with lower than average annual precipitation. The mean lamb:ewe ratio in area #2, pooled for 29 years, was 22:100 ( $n = 646$ ). The sheep were protected from hunting, but were subject to a full range of indigenous carnivores. However, predation did not appear to be the primary cause of the declines, nor was competition for forage with American Elk (*Cervus elaphus*).

**Key Words:** Bighorn Sheep, *Ovis canadensis*, winter range, predation, Jasper National Park, Alberta.

Alberta's population of Bighorn Sheep (*Ovis canadensis*) was estimated at 11 500, which is roughly 25% of the North American total (Wishart 1999). The province has been the setting of several intensive research projects, including the capture and tagging of entire local populations (Festa-Bianchet 1991; Jorgenson et al. 1993; Festa-Bianchet et al. 1996; Jorgenson et al. 1997; Portier et al. 1998; Wishart et al. 1998). This research resulted in the accumulation of a vast amount of data on density-dependent growth rates, productivity, individual survival, and disease. Sexual segregation of mature rams and ewes was found to be based on differing nutritional demands and time budgets (Ruckstuhl 1998), and sexual segregation was identified as an important adaptive phenomenon in the ecology and distribution of bighorns that affects foraging efficiency, movement patterns, and predator avoidance (Geist 1971; Ruckstuhl and Festa-Bianchet 2001).

Risk of predation by cursorial carnivores forces mountain-dwelling sheep to stay close to steep escape terrain, where forage may be in limited supply (Murie 1944). Although the anti-predator strategies of bighorns are quite effective against canids, they provide no security from ambush predators, such as the Cougar (*Puma concolor*). Sheep mortality caused by Cougars has been studied in Alberta and elsewhere (Ross et al. 1997; Rominger et al. 2004). Based on stochastic predation events at two sites in Alberta, Festa-Bianchet et al. (2006) hypothesized that the viability of small, isolated sheep populations is at risk and that these populations could face serious decline or even local extinction if individual Cougars specialize on sheep prey. Festa-Bianchet et al. (2006) further suggested

that “predator-prey equilibria may only exist at large geographical and temporal scales” and equilibrium is unlikely in view of increasing habitat fragmentation.

The purpose of the present study was the long-term monitoring of a localized Bighorn Sheep population wintering in Jasper National Park of Canada, which contains the largest contiguous and protected bighorn range in North America today. The sheep are subject to predation by a full complement of indigenous carnivores, including Wolves (*Canis lupus*), Coyotes (*Canis latrans*), and Cougars. Unlike other locations in Alberta, the study area has not been subject to hunting or known outbreaks of contagious disease. Furthermore, and again unlike other Alberta populations, the sheep in Jasper National Park have not been studied closely since the 1970s.

During the 1940s and 1960s, Canadian Wildlife Service biologists working in the park repeatedly argued that overpopulation by American Elk (*Cervus elaphus*) was having a serious negative impact on Bighorn Sheep and that the problem was being compounded by the recent return of the Wolf (Cowan 1947). Stelfox (1978) warned that the bighorn population of Athabasca valley in the park was at risk of a major die-off because of competition from Elk for forage on shared and severely overgrazed winter range. However, conditions improved after Elk numbers fell steeply in the 1970s due to a series of severe winters with record snow coupled with a surge in Wolf numbers (Dekker et al. 1995).

In addition to presenting sheep numbers over 29 consecutive years, this study reports on (1) carnivore predation on sheep, (2) local Elk numbers and the

potential for competition for forage between Elk and Bighorn Sheep, and (3) deterioration of the range due to a noxious weed infestation and a period of drought. Long-term naturalistic field studies such as this are crucial to provide the data and insights required to understand the impact of climate change on the living world (Jensen 2004). They are all the more important today because our last remaining wild places are continuing to be destroyed at an unprecedented rate (Schmidly 2005).

### Study Area and Methods

Jasper National Park is 10 880 km<sup>2</sup> in size and is situated in west-central Alberta between 52°29' and 52°08' north latitude. Elevations range from a peak of 3747 m in the west to a low of 990 m in the east. The three main ecoregions are alpine, subalpine, and montane. Of these, the montane is the smallest in extent but of critical importance, containing the richest diversity of flora and fauna and providing vital wintering range for the park's large mammals, which include seven species of ungulates. For a detailed description of the park's habitats and wildlife inventory, see Soper (1970) or Holroyd and VanTighem (1983).

During the past 150 years, numbers of Bighorn Sheep have fluctuated markedly in the national parks in the Rocky Mountains in Alberta, from near extirpation due to hunting in the 1800s to an apparent overpopulation after severe Wolf control campaigns in the 1950s (Stelfox 1971; Gunson 1992). However, in response to protective measures, the large mammal system of Jasper National Park eventually recovered, and the period from 1967 to 1987 appears to have been quite stable. An aerial survey flown along 20 mountain ranges in January 1967 produced a total estimate of 2011 sheep (Stelfox 1971). Twenty years later, park wardens flew the same ranges and tallied 2278 sheep (Wes Bradford, personal communication.).

The Bighorn Sheep is the most numerous species of ungulate in Jasper National Park. Occurring mainly in the front ranges, sheep reach their highest concentrations in the lower Athabasca River valley (Cowan 1947; Soper 1970; Holroyd and VanTighem 1983). Varying in height and aspect, the east-facing slope of the Athabasca valley rises to 200–300 m above the montane bottomlands and is characterized by a mosaic of coniferous forest, open slopes, and rocky outcrops. From October to April and during part of the summer months each year, sheep occur all along this 20-km escarpment, from the Snaring River to the park's east gate, and possibly well beyond. However, during winter, they are concentrated at traditional points that include steep escape terrain as well as exposed grassy slopes where frequent Chinook winds reduce snow cover. Two such areas were selected for this study. They are about 2 km apart and both contain roughly 100 ha of open, grassy terrain. Site #1 is called Ram Pasture and site #2 the Canyon. At the base of both

hillside pastures are limestone cliffs 30–50 m high.

The methodology in this study was designed to cause a minimum of human disturbance. The study area was a relatively remote corner of the park accessed on foot. At the Ram Pasture, sheep were observed from the wooded upper ridge, which gave a clear view of the grassy slopes below. The sheep were not shy and tolerated a close approach. The Canyon is a steep, south-facing slope that can be viewed from a hillside bluff on the opposite side of the Snake Indian River valley. The same hill served as a lookout point from which the adjacent river flats and semi-open montane meadows were scanned. All mammals seen were recorded in a diary and entered into the logbook of the district's patrol cabin.

Between mid-October and the end of March from the winter of 1981–1982 to 2009–2010, the study area was visited 9–12 times each year. Each visit included one to three overnight stays. Over 29 years of this 30-year period (no data were collected in 2007–2008), the accumulated number of full days afield was 627. During each visit, area #1 was walked at least once. Area #2 was checked twice a day, in early morning and again in the evening. Each check involved one hour of scanning the canyon and the flats through binoculars. In total, the Canyon viewpoint was manned approximately 1300 times over the study period. For each year, records were kept of the maximum number of sheep in the Canyon band—including ewes, lambs and yearlings—while rams with horns larger than those of mature ewes were deleted from the total. For 100% reliability, classified counts were restricted to opportunities when all members of a discrete group, no matter its size, were in good view. The lamb:ewe ratios were pooled per year irrespective of possible duplication, and the accumulated total for the 29 years was tabulated per month from October to March.

The study area is a major wintering range for Elk (Dekker et al. 1995). The maximum observed size of the local Elk cow herd was used as a parameter of population size for each winter. Other ungulates common in the study area are Mule Deer (*Odocoileus hemionus*) and White-tailed Deer (*Odocoileus virginianus*), which were counted separately but not reported here. The local Wolf population was assessed on the numeric size of the largest pack seen, and Coyote presence was based on sightings per field day. Most of these data have previously been published (Dekker 1989, 1998) and were included in (unpublished) reports for the Jasper National Park warden office (Dekker 2001\*, 2008\*).

In addition to sheep numbers, this study includes cursory information on range conditions on the Ram Pasture, the Canyon, and the adjacent montane meadows. Annual precipitation totals were obtained from Environment Canada for recording stations closest to the study area (East Gate and Jasper Warden Station). Some values were compared statistically with a chi-



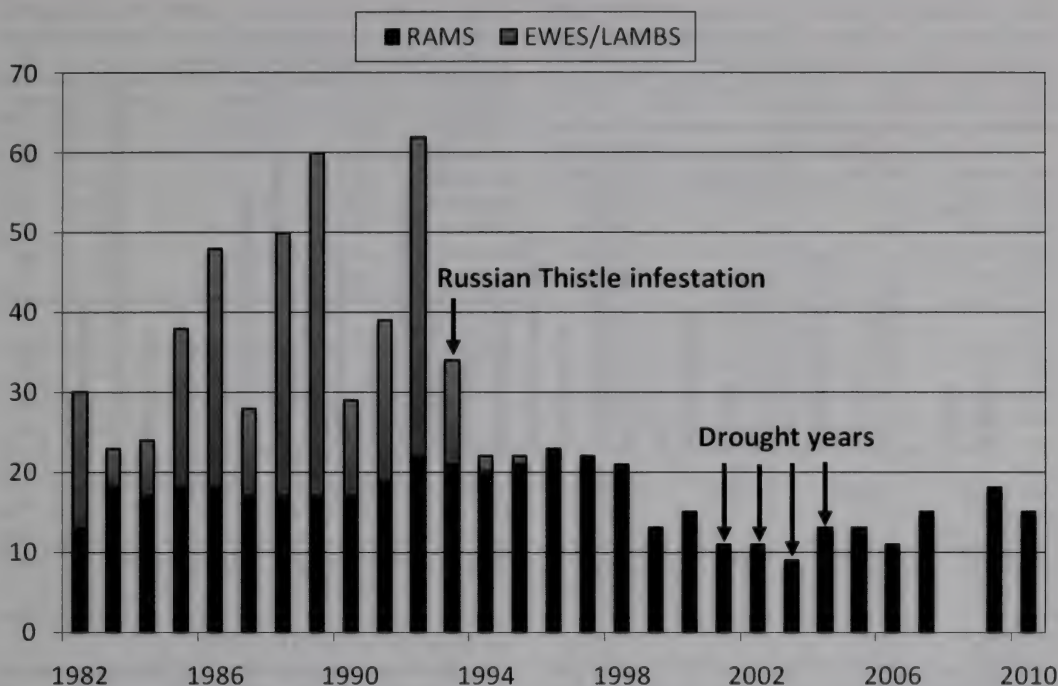


FIGURE 1. Maximum band sizes per annum of two segregated groups of Bighorn Sheep at the Ram Pasture wintering range in Jasper National Park, Alberta. The disappearance of the nursery band coincided with a serious outbreak of Russian Thistle (data for 2008 were not available).

squared contingency test and a Student *t*-test on sample mean differences.

## Results

Study area #1 (the Ram Pasture) is the traditional winter range for a group of mature rams. During October, the odd ram might be present but he would subsequently leave again in advance of the November mating season. By mid-December, rams had begun to arrive singly and they eventually assembled into a cohesive band that stayed well beyond the end of March. The maximum size of the ram band changed little from year to year, and the annual mean remained at 18 over 20 winters (Table 1). After 2001, the number of rams declined significantly to a 5-year mean of 11 ( $t = 6.28$ ,  $P < 0.001$ ) but recovered slightly in the years 2007–2010. Prior to 1995, the Ram Pasture was also used by a nursery band of ewes, yearlings, and lambs (the ewe band). The maximum size of this band fluctuated between years (Table 1). From the winter of 1981–1982 to the winter of 1992–1993, the annual mean size of the ewe band was 23, but in the winter of 1994–1995, only two ewes were seen, and the following winter only one. From 1995 to 2010, not a single ewe, yearling, or lamb was recorded on the Ram Pasture (Figure 1).

Study area #2 (the Canyon) was frequented by one or more mature rams during the fall mating season, but rarely after December. On occasion, rams were observed traveling from the Canyon to Ram Pasture; this involved traversing several narrow belts of forest. Groups of ewes, yearlings, and lambs could be seen on the Canyon slopes at any time of the year. From October to March, the maximum size of the band varied greatly from day to day as well as from year to year, but the 5-year running mean stayed roughly the same during the first 20 years at 40 until it dropped significantly to 24 in the period 2001–2010 ( $t = 1.83$ ,  $P < 0.01$ ). During the last two years of the study, the ewe band declined to one-third of its former size (Table 1).

The lamb:ewe ratio on the Ram Pasture (over the 12 winters that the local ewe band persisted) was 24:100 ( $n = 128$ ), nearly identical to the 22:100 ( $n = 791$ ) recorded at the Canyon over the 30 years of the study (Table 2). The accumulated figures for October were 30:100 ( $n = 265$ ), higher than the 19:100 for March ( $n = 225$ ), but the difference was not significant ( $P > 0.15$ ).

The local Elk herd was monitored concurrently with the sheep census. Here, too, the sexes were segregated, with mature Elk bulls widely scattered and

TABLE 1. Maximum recorded band sizes per year and 5-year running means of the Bighorn Sheep population at two adjacent but discrete wintering ranges in the lower Athabasca River valley of Jasper National Park, Alberta, 1981–2010 (data for 2008 were not available).

Year (winter)	Study site #1		Study site #2
	Ram band	Ewe band	Ewe band
1981–1982	13	17	29
1982–1983	18	5	75
1983–1984	—	—	25
1984–1985	18	20	31
1985–1986	18	30	23
Mean	16.8	18.0	36.6
1986–1987	—	—	54
1987–1988	17	33	77
1988–1989	17	43	38
1989–1990	17	12	40
1990–1991	19	20	21
Mean	17.5	27.0	46.0
1991–1992	22	40	54
1992–1993	21	13	31
1993–1994	20	2	26
1994–1995	21	1	30
1995–1996	23	0	45
Mean	21.4	11.2	37.2
1996–1997	22	0	26
1997–1998	21	0	55
1998–1999	13	0	61
1999–2000	15	0	24
2000–2001	11	0	28
Mean	16.4	0	38.8
2001–2002	11	0	14
2002–2003	9	0	33
2003–2004	13	0	27
2004–2005	13	0	40
2005–2006	11	0	15
Mean	11.4	0	25.8
2006–2007	15	0	36
(Not available)			
2008–2009	18	0	14
2009–2010	15	0	14
Mean	16.0	0	21.3

the cows staying together in one or two groups. The cow herd included calves as well as yearlings of both sexes. Its maximum size remained remarkably stable, with an annual mean of 49 animals during the first 20 years. In the period 2001–2010, the size of the cow herd dropped to a mean of 38. However, the decline was not significant ( $t = 1.70$ ,  $P < 0.06$ ).

As for the local predators, there is no information on the size of the Cougar population in Jasper National Park. During this study, one or more Cougars were tracked each winter and were seen on seven different occasions. Wolves were recorded, either by tracks or sightings, during all visits. Western Wolves show a wide spectrum of colour variants, from white to black, and packs are territorial (Dekker 1989, 1998). Repeat sightings of recognizable animals indicated that the study area was frequented by only one dominant pack.

TABLE 2. Lamb:ewe ratios for Bighorn Sheep by month, pooled for 29 consecutive years, at the Canyon wintering range in Jasper National Park, Alberta.

Month	Ewes	Lambs	Lambs/100 ewes
October	204	61	30
November	125	22	18
December	45	9	20
January	28	5	18
February	55	12	22
March	189	36	19
Total	646	145	22

However, during the winters of 1996–1997, 1997–1998, and 1998–1999, a second group was occasionally sighted, containing 9, 5, and 2 members, respectively. Between 1981 and 2001, the maximum size of the territorial pack ranged from 2 to 13, with a mean of 7.8. In the period 2001–2010, the mean dropped to 4.0. The decline was significant ( $t = .81$ ,  $P < 0.01$ ). The Coyote population also declined over the course of the study. Between 1981 and 2001, a total of 119 Coyotes was sighted over 542 observation days, averaging 0.2 Coyotes per day, but this dropped to 0.03 Coyotes per day in the period 2001–2010.

Weather data, obtained from Environment Canada, indicate that annual precipitation decreased from a 35-year mean of 569 mm in the period 1971–2006 to a mean of 430 mm in the period 2001–2004. These four years represented a major deviation from normal precipitation patterns, and the Student  $t$ -test showed a high degree of significance ( $t = 7.52$ ,  $P < 0.001$ ). The last two years, 2008 and 2009, were again very dry, with 306 and 194 mm of annual precipitation, respectively, the lowest amounts recorded at Jasper since 1971.

## Discussion

The decline of this bighorn population between 2001 and 2010 is all the more remarkable because of the population's stability during the previous 20 years. To explain the decline, by way of hypothesis, the various proximate factors that can negatively affect sheep dynamics, apart from disease, are (1) population density, (2) fecundity, (3) competition for forage from other grazers, (4) predation, and (5) poor habitat (Cowan 1947; Stelfox 1971; Geist 1971; Jorgenson et al. 1997; Festa-Bianchet et al. 2006).

Theoretically, bighorn herds have the potential to double their numbers in about three years, but that rate of increase cannot be reached on inadequate range (Wishart et al. 1998). To reduce the risk of predation, sheep confine themselves to islands of suitable habitat, which soon become overpopulated. This in turn leads to a reduction in pregnancy rates, stunted growth of yearlings, and poor lamb survival (Geist 1971). An indication that the bighorns in Jasper National Park were affected by one or more of the above limiting factors is their low lamb:ewe ratio.



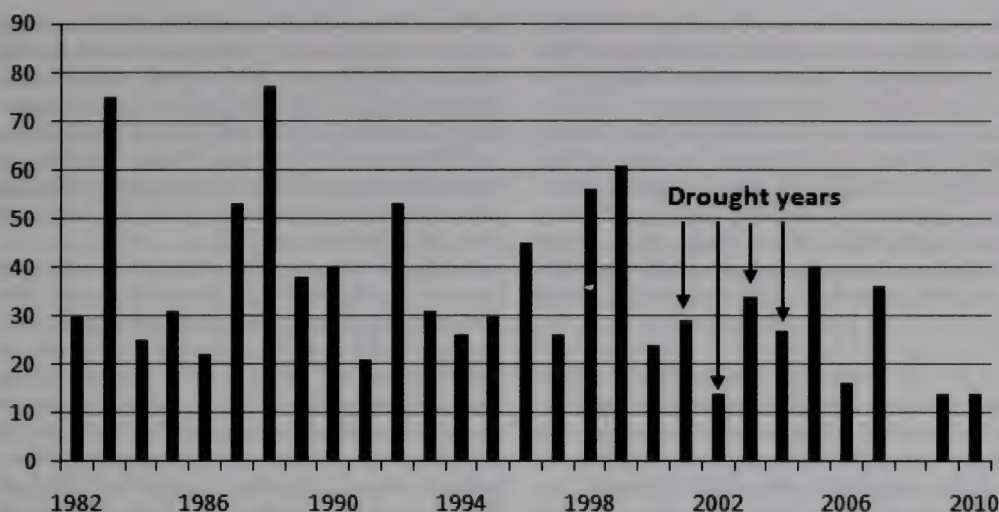


FIGURE 2. Maximum size per year of the Bighorn Sheep nursery band (including yearlings and lambs) at the Canyon wintering range, 1981–2010 (data for 2008 were not available). During the drought years of 2001–2004, the steep south-facing slope became practically denuded of forage plants.

Ratios reported by other researchers in Jasper National Park and Banff National Park of Canada, obtained from various localities and at various times of year, range from 15 to 51 lambs per 100 ewes (Holroyd and VanTighem 1983). For comparison with the results reported in this paper, the most relevant survey data, dating back to 1978–1979, are from the lower Athabasca valley in Jasper National Park. Monthly counts from October to March yielded an accumulated ratio of 31 lambs per 100 ewes. However, unlike the results of this study, those data did not include yearlings. If the yearlings, which were counted separately by Holroyd and VanTighem (1983), are added, the adjusted ratio is 27:100, which is still higher than the 29-year mean of 22:100 found in this study.

#### *Range competition from Elk*

There is no evidence to suggest that the decline in the sheep population may have been caused by competition with Elk for range. On the contrary, based on maximum herd sizes per annum, the Elk population changed very little between 1981 and 2001, until it too dropped during the drought of 2001–2004. The decline in Elk parallels the decline in sheep and points away from interspecific forage competition. Furthermore, the Elk grazed mainly on the flats, away from the hills where the sheep were. The underlying factor affecting the decline of both species simultaneously may well have been either one or both of the next two potentially limiting factors: predation and deterioration of the winter range.

#### *Predation*

Predation by large carnivores is considered a major determinant in the demographics of ungulate popula-

tions (Mech and Peterson 2003). It has been the subject of much research, and a short list of relevant citations here would inevitably be incomplete. Instead, this discussion will be limited to what is known about predation on Bighorn Sheep in Alberta.

**Cougar Predation.** At two localities, telemetry studies revealed that individual Cougars were having a major impact on small, isolated populations of sheep (Festa-Bianchet et al. 2006). The declines were halted after the death of these individual Cougars. However, in most years of their long-term study, Festa-Bianchet et al. (2006) reported no Cougar predation on sheep. Apparently, these ambush predators preyed mostly on deer (Ross and Jalkotzy 1992). This may well have been the case in the current study area.

During this study, Cougars were spotted three times on the Canyon slope and three times on the Ram Pasture, where they were seen feeding on the carcasses of sheep. Two of these might have been casualties of the railway that runs by the Ram Pasture. In only one case it appeared that the sheep, a mature ram, had actually been killed by the Cougar.

**Wolf Predation.** During this study only two mature rams are known to have been killed by Wolves, which were observed feeding on their prey. The rarity of these predation events was all the more surprising considering the high Wolf presence. The Ram Pasture was on a well-used Wolf travel route, and there appeared to be an obvious connection between sheep behaviour and Wolf visits. If all of the rams were standing on or close to the cliff, tracks in snow often revealed that Wolves had recently passed by. Conversely, if the

Wolves had not been there for some time, the ram band would be grazing well away from the cliff on the higher slopes or even in adjacent woods (Dekker 2002). Bighorn Sheep have excellent eyesight and they are very alert to canids (Geist 1971). At Sheep River in southern Alberta, where Wolves are rare, sheep often forage in the woods (K. Ruckstuhl, personal communication). However, in localities where predators are common, sheep tend to frequent open terrain. Based on this study, predation rates on rams appear to be low. In most years, ram band numbers stayed the same from mid-February to the end of March.

Although Bighorn Sheep are vulnerable to ambush hunters like the Cougar, Festa-Bianchet et al. (2006) postulated that the anti-predator strategies Bighorn Sheep use are effective against cursorial predators such as Wolves. The above researchers did not present evidence or cite supportive publications. It appears that first-hand information on Wolf–bighorn interaction is rare, not only because most of North America's bighorn habitat lies outside the current range of Wolves, but also because their interactions are seldom witnessed. Even in Jasper National Park, where both species are common, there are very few observations of Wolves attacking sheep (Jasper National Park warden Wes Bradford, personal communication). Following are two Wolf–sheep interactions recorded in recent times.

In October 1990, a lone Wolf was seen and photographed in close pursuit of several ewes and lambs on the steep road escarpment above Medicine Lake (see photo in Dekker 1997: 107). The Wolf failed to catch a sheep and fell partway down the rocky slope, but did not appear to have injured itself (Jasper National Park biologist Ward Hughson, personal communication).

During this study, on 30 March 2007, a band of 26 ewes, yearlings, and lambs standing on the Canyon hillside were looking down at a Wolf walking along the cliff top some 80 m below the sheep. Suddenly, the Wolf sprinted up the steep slope. The band reacted by splitting into two groups, and half a dozen sheep ran downhill, bypassing the predator. The Wolf turned and sprang down after the fleeing sheep, but in vain. After three similar assaults, the entire band had managed to bypass the attacker and reach the safety of the canyon cliffs.

Cowan (1947) elaborated on the apparent ability of Bighorn Sheep to avoid Wolves. His list of 118 ungulates killed by Wolves in Jasper National Park and Banff National Park contained only 10 bighorns (9%), and the percentage of sheep in his sample of Wolf scats ( $n = 358$ ) collected by park wardens was 7%. Thirty years later, Carbyn (1975) reported less than 10% sheep hair in his sample of Wolf scats from Jasper National Park, and he found no sheep kills at all by snow-tracking Wolf packs. Similarly, there were no sheep in a sample of 53 ungulates killed by Wolves

in Jasper National Park from 1999 to 2001, and there were only 4 sheep in 176 Wolf kills found in Banff National Park between 2000 and 2005 (Banff National Park biologist J. Whittington, personal communication). These very low percentages suggest that Wolves kill few sheep compared to other hoofed mammals, all the more revealing in view of the fact that the bighorn is the most numerous ungulate in both Jasper National Park and Banff National Park.

Holroyd and VanTighem (1983) also noted the low incidence of bighorns in the diet of Wolves in Jasper National Park, although they cited several cases where sheep away from steep escape terrain had been surprised by Wolves. Sheep may be hunted relatively more frequently in habitats where other ungulates are scarce, for instance, in the narrow valley of the Fiddle River (Jasper National Park warden Greg Slatter, personal communication) or in alpine regions. In 1984–1985, provincial researchers flying helicopter surveys observed Wolves chasing sheep above the tree line on the eastern boundary of Jasper National Park (Schmidt and Gunson 1985).

#### *Coyote Predation.*

The most dangerous predator of sheep is possibly the Coyote. More common than either Cougar or Wolf, it may also be more agile in the kind of rough terrain that sheep inhabit. Holroyd and VanTighem (1983) cited several instances in which Coyotes were observed killing Bighorn Sheep. In this study, a Coyote was seen on a freshly killed ewe lying on the river ice below the Canyon cliffs (B. Genereux, personal communication). Elsewhere, on the opposite side of the Athabasca valley, a Coyote killed two lambs within 20 minutes (Dekker 1986).

The decline in Coyotes in the study area, based on sightings per day, was not limited to the last five years, but extended over the entire study period. The probable cause is hostile interaction with Wolves, which are known to kill Coyotes (Ballard et al. 2003). However, the decline accelerated significantly ( $t = 4.1$ ,  $P < 0.001$ ) between 2001 and 2006, suggesting that the drought was having an additional negative impact on Coyotes, possibly related to a decrease in small rodent prey. During the period 2001–2010, Red Foxes, *Vulpes vulpes*, also became increasingly rare, as indicated by scarcity of tracks.

#### *Range Deterioration and Drought*

The most obvious and significant negative factor affecting the sheep on the Ram Pasture was the decline in the quality of the forage due to the spread of a noxious weed commonly called Russian Thistle or Tumble Weed. The problem was first identified in 1993, but the infestation must have started earlier. By 1994, some 20–40% of the slopes at Ram Pasture were covered with this prolific annual (Dekker 1995\*). When young, the seedlings are soft and green and can be eaten by herbivores, but over summer the stems become



brittle and the leaves harden into thorns that are unpalatable. On livestock ranges, this noxious weed is considered an indicator of overgrazing (D. Johnson, Natural Resources Canada, personal communication). On the Ram Pasture, the thistles probably invaded when the range was frequented by both rams and ewes. Interestingly, the departure of the local ewe band coincided with the thistle outbreak (Figure 2). By 2006, after grazing pressure had lessened, the thistles were again replaced by grasses, followed by a slight increase in the number of wintering rams (Table 1).

The thistles did not spread to the Canyon site. However, in 2001, an equally if not more serious negative factor became apparent: drought. The annual precipitation totals for the period 2001–2004 were 414 mm in 2001, 417 mm in 2002, 470 mm in 2003, and 419 mm in 2004, well below the 35-year mean of 569 mm. During these drought years, while the band size declined significantly, the denuded Canyon slopes turned to dust. Scraping for plant roots, the sheep aggravated the problem. Eventually, the ewes all but abandoned the eroding slopes. On nine visits between 2001 and 2010, I spotted no sheep on the Canyon site. Prior to 2001, they had been present every day.

Due to their southeasterly aspect, the Ram Pasture and the Canyon were severely affected by the lack of rain, but the montane meadows were drying up as well. Groundcover withered, with bare soil showing between the vegetation. The plant succession during early summer included drought-resistant and unpalatable species such as Pasture Sage (*Artemisia frigida*) and Owl Clover (*Orthocarpus luteus*), which is more typical of semi-arid prairie habitats (Cormack 1977).

### Conclusion

In summary, it is remarkable that the sheep numbers were stable from 1981 to 2001 in spite of the presence of predators. This finding supports the hypothesis, advanced by Festa-Bianchet et al. (2006), that predator–prey equilibria can exist at large geographical and temporal scales. The low lamb:ewe ratios were apparently adequate to maintain the population, at least prior to the drought years. Similarly, low recruitment levels in British Columbia (24 juveniles to 100 females) were reportedly sufficient to balance predation losses in a multiple ungulate prey system that included Thinhorn Sheep (*Ovis dalli stonei*) (Bergerud and Elliott 1998).

What is unknown is whether the localized drop in sheep numbers reported here is indicative of a real decline in the mega population of Jasper National Park bighorns. Ewes abandoning the study area might have wintered elsewhere. On the Canyon, bands were often observed to come and go. Some left in a northwesterly direction following the high banks of the Snake Indian River; others moved out of sight along the Athabasca escarpment. Overall stability of the larger population in Jasper National Park is suggested by the stability of the numbers of the ram band, which changed rela-

tively little over the 30 years. Unfortunately, nothing is known about the greater territory of these rams and the distances they travel in order to meet up on their traditional winter range at Ram Pasture. Research is needed to see whether they and the ewe bands will again increase if annual precipitation totals return to or exceed the long-term mean and lead to recovery of the damaged Canyon slopes. At the termination of this long-term study, the prospects seemed bleak. In 2008 and 2009, annual precipitation totals for Jasper National Park were 306 and 194 mm, respectively, the lowest recorded since 1971.

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## Notes

### Sexual Size Dimorphism and Bohemian Waxwings, *Bombycilla garrulus*

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Ludlow, Sarah M. 2009. Sexual size dimorphism and Bohemian Waxwings, *Bombycilla garrulus*. Canadian Field-Naturalist 123(2): 165–167.

Sexual size dimorphism is common among birds, with males generally being larger than females. Sexual size dimorphism is typically more extreme in polygynous species; socially monogamous males are typically only 5% larger than females. However, cryptic sexual size dimorphism has been found in some socially monogamous species. I used standard external measurements as well as two internal measurements (keel length and pectoral muscle mass) to determine whether, or to what extent, Bohemian Waxwings (*Bombycilla garrulus*) exhibit sexual size dimorphism. Males were only slightly larger than females in all of the characters measured except keel and tarsus length. Keel and tarsus length were 0.6% and 1% longer, respectively, in females than in males. The similar size exhibited by males and females may be related to the amount of parental care provided by males. Smaller body size in males may reflect a trade-off between selection for increased male size and energetic constraints imposed by parental care.

**Key Words:** Bohemian Waxwing, *Bombycilla garrulus*, sexual size dimorphism, Saskatchewan.

Sexual size dimorphism is common among birds, with males generally being larger than females (Murphy 2007). Sexual selection theory is often used to explain sexual size dimorphism in birds and other animals (Hendrick and Temeles 1989). If competition is greater in one sex than the other, sexual selection should result in a larger body size in the more competitive sex (Székely et al. 2000; Kissner et al. 2003). For example, if successful competition for females is partially determined by body size, then larger males will obtain more mates, thus selecting for larger body size in males (Webster 1992). The type of mating system strongly influences sexual dimorphism in general, with polygynous species often exhibiting extreme cases of sexual dimorphism (Dunn et al. 2001). In contrast, sexual dimorphism in monogamous species is rare and subtle (Webster 1992). Sexual size dimorphism may also arise through natural selection via ecological differences between the sexes. For example, if both parents tend the nest, selection could result in different sizes between the sexes in order to reduce intra-pair competition for food and other resources (Andersson and Norberg 1981; Székely et al. 2000). In general, the effects of sexual and natural selection are often related and difficult to separate, so it is likely that sexual size dimorphism results from a combination of these two factors.

Among socially monogamous species, males are on average ~5% larger than females (Murphy 2007). However, it is possible that socially monogamous species are more sexually size dimorphic than initially assumed. For example, extensive analyses of bird body

components revealed that the socially monogamous Eastern Kingbird (*Tyrannus tyrannus*) exhibits cryptic sexual size dimorphism, despite the fact that there are no sexual differences in body mass or standard external measurements (Murphy 2007). Clearly, a re-evaluation of the current contention that sexual size dimorphism is rare or subtle in socially monogamous species is required. The objective of this study was to determine the extent of sexual size dimorphism in the socially monogamous Bohemian Waxwing (*Bombycilla garrulus*). Although females are slightly smaller, there is no significant difference in the body mass or standard external measurements of male and female Bohemian Waxwings (Witmer 2002).

#### Materials and Methods

I obtained Bohemian Waxwing specimens from the Royal Saskatchewan Museum (RSM), Regina, Saskatchewan, in September 2007. Total sample size consisted of 19 wild birds donated to the museum over the past two decades from locations throughout the province. Birds were aged and sexed based on plumage (Pyle 1997), and sex was confirmed upon dissection. In order to reduce any size variation due to age, I used only adult birds; all birds available were able to be included. I measured external and internal characteristics to compare the sexes. External measurements included body mass, wing chord, tail length, tarsus length, bill height, and bill width. Tarsus length, bill height, and bill width were measured using digital calipers to a precision of 0.01 mm; wing chord and tail length were measured with a 15.24 cm and 1 m

TABLE 1. Comparisons of body mass, lengths of external and internal characters, and oven-dried pectoral muscle mass (ODPMM), in male ( $n = 10$ ) and female ( $n = 9$ ) Bohemian Waxwings.

Character	Male (mean $\pm$ SE)	Female (mean $\pm$ SE)	$t$ ( $P$ )	Sexual size dimorphism index	Percentage difference	Male Confidence interval		Female Confidence interval	
						lower	upper	lower	upper
Body mass (g)	57.8 $\pm$ 2.4	56.4 $\pm$ 1.3	0.63	0.024	2	53.10	62.50	53.85	58.95
Wing chord (mm)	116.6 $\pm$ 0.8	114.4 $\pm$ 1.1	0.14	0.019	2	115.03	118.17	112.24	116.56
Tail length (mm)	63.8 $\pm$ 1.2	60.8 $\pm$ 1.1	0.09	0.047	5	61.45	66.15	58.64	62.96
Tarsus length (mm)	24.90 $\pm$ 0.64	25.17 $\pm$ 0.73	0.79	-0.011	1	23.65	26.15	23.74	26.60
Bill height (mm)	6.00 $\pm$ 0.17	5.79 $\pm$ 0.26	0.51	0.036	4	5.67	6.33	5.28	6.30
Bill width (mm)	11.15 $\pm$ 0.65	10.58 $\pm$ 0.22	0.44	0.051	5	9.88	12.42	10.15	11.01
Keel length (mm)	30.21 $\pm$ 0.54	30.4 $\pm$ 0.56	0.83	-0.006	0.6	29.15	31.27	29.30	31.50
ODPMM (g)	3.9 $\pm$ 0.2	3.9 $\pm$ 0.1	0.81	0.0	0	3.61	4.19	3.70	4.10

ruler, respectively. Internal measurements included the length of the keel and the pectoral muscle mass. Keel length was measured from the base of the furcular depression to the base of the sternum. The pectoral muscles were removed and placed in a drying oven for 48 hours to reduce any variability due to moisture content. The oven temperature was 450°C for the first 24 hours, then 500°C for the next 24 hours. All samples were weighed with a triple beam balance to a precision of 0.01 g to obtain oven-dried pectoral muscle mass (ODPMM) values for each bird.

I used two-tailed, two sample  $t$ -tests assuming equal variance in order to compare mean values between the sexes. I also calculated 95% confidence intervals for the mean of each trait to determine whether any overlap occurred between males and females. I calculated a sexual size dimorphism index (SSDI) for each trait by dividing the size of the trait in the larger sex by the size of the trait in the smaller sex, then subtracting one from the quotient (Lovich and Gibbons 1992). The SSDI indicates the degree of difference between the sexes.

## Results and Discussion

Of the 19 birds, there were 9 females and 10 males. Specimens were primarily collected from Regina (50°27'N, 104°37'W), with some from Fort Qu'Appelle (50°77'N, 104°28'W) and Whitewood (50°20'N, 102°15'W); data on collection location were not available for all specimens.

Overall, I found that males were larger than females, but females had slightly longer keels and tarsi (Table 1). However, the difference between males and females was typically < 5%, similar to that found for other socially monogamous birds (Murphy 2007).

Sexual size dimorphism is reduced in males that play a substantial role in parental investment because a smaller body size is less energetically costly and should be favoured by selection (Mosher and Matray 1974; Hughes and Hughes 1986; Jönsson and Ålerstam 2008). Male Bohemian Waxwings contribute substantial amounts of parental care, so it is reasonable

that males are not much larger than females. Males deliver food to the female during the incubation and early nestling period, and both parents feed the young (Semenchuk 1992; Witmer 2002). Thus, a smaller body size minimizes the male's metabolic needs, thereby enhancing his ability to provide for the female and chicks and potentially increasing his reproductive success as a result.

Sample size was limited to the number of birds available from the RSM. Although juveniles were excluded, a difference in size due to age likely still affected the results. A larger sample size would have allowed further division based on age (i.e., second-year and after-second-year birds). The result may also be biased due to collecting, specifically, if smaller or less fit males are more likely to be collected, then only small males would have been compared with females. It would be interesting to investigate this topic further to determine whether age-related size differences influence the degree of sexual size dimorphism in Bohemian Waxwings, as well as other birds.

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## Complete Albinism in a Northern Red-backed Vole, *Myodes rutilus*, in Alaska

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Whitman, Jackson S. 2009. Complete albinism in a Northern Red-backed Vole, *Myodes rutilus*, in Alaska. *Canadian Field-Naturalist* 123(2): 167-168.

During a study of small mammal abundance and species composition in interior Alaska, I collected a Northern Red-backed Vole (*Myodes rutilus*) showing complete albinism. This report documents that extremely rare occurrence, with notes on habitat and morphometrics.

Key Words: *Myodes rutilus*, Northern Red-backed Vole, albino, Alaska.

True albino, or amelanistic individuals are caused by a genetic trait and are completely devoid of melanin. Characteristically they have unpigmented pink eyes. Mammals with this trait display white pelage. Albinism, either partial or complete, is rarely documented in wild populations, thus detailed observations are noteworthy.

I captured a single complete albino Northern Red-backed Vole (*Myodes rutilus*) in a Museum Special snap trap (Woodstream Corporation, Lititz, Pennsylvania, USA) baited with a combination of peanut butter and rolled oats on 2 August 2007 on Minto Flats State Game Refuge, central Alaska (64.9052°N, 149.0309°W). Dental characteristics and skull morphology confirmed the initial species classification. The albino Northern Red-backed Vole had complete white pelage and pink eyes, with standard body measurements well within the norm displayed by other conspecifics in interior Alaska. Testes were non-scrotal, indicating a juvenile male individual. Weight was 17.4 g, with standard measurements (mm) of 119:29:

19:14 (total:tail:hind foot:ear). In a sample of 111 individuals captured during 2007, weights averaged 20.9 g, with extremes from 7.9 to 36.7 g. Standard measurements from this population sample show means of 120.0:29.7:18.9:14.4 (Whitman, unpublished data). This specimen was submitted for curation to the University of Alaska Museum of the North (UAM 85050).

During 2003-2007, 7926 trapnights using unmodified Museum Special snap traps resulted in captures of 925 Northern Red-backed Voles. An additional 107 individuals were captured in 980 pitfall trapnights (1 capture/8906 trapnights; 1 albino in 1032 *M. rutilus* captured = 0.097%). No other Northern Red-backed Voles showed any degree of albinism. A check for albinism amongst 1653 Northern Red-backed Vole records in the University of Alaska Museum of the North revealed six specimens, two of which appeared to be complete albinos. However, I suspect any inference to natural population incidence is negated by the fact that pelage morphs are more likely to be curated than "normal" specimens.

Habitat from which the albino Northern Red-backed Vole came was interior boreal forest at 110 m elevation. No notable logging or other anthropogenic changes have occurred within 10 km of the site. Overstory vegetation was composed of an open mixed forest of Alaska Paper Birch (*Betula neoalaskana*) and White Spruce (*Picea glauca*) with approximately 50% canopy closure. The understory (stems per 1-m-radius plot frame) was comprised of Labrador Tea, *Ledum groenlandicum* (90 stems, 59% of total stems), Mountain Cranberry, *Vaccinium vitis-idaea* (30, 20%), Bog Blueberry, *Vaccinium uliginosum* (22, 14%), and minor amounts of grass, *Calamagrostis* sp. (5, 3%), Horsetail, *Equisetum* sp. (4, 3%), and Red-fruited Bastard Toadflax, *Geocaulon lividum* (2, 1%). Plant systematics and nomenclature follows Hultén (1968) with updates provided by Viereck and Little (2007). Habitat suitable for Northern Red-backed Voles occurs in a continuum on the north side of the Alaska Range through Alaska and eastward into Yukon Territory, Canada, thus, this individual was not likely from a geographically isolated population.

Although there are numerous references to albinism in various microtine populations (*Microtus montanus*: Warren 1929; Pinter and Negus 1971; Jannett 1981; *M. ochrogaster*: Pinter and Negus 1971; *M. pennsylvanicus*: Owen and Shakelford 1942; Barrett 1975; Brewer et al. 1993; Parsons and Bondrup-Nielsen 1995; *M. pinetorum*: Schantz 1960; Paul 1964; *Clethrionomys (Myodes) gapperi*: Bowman and Curran 2000), the incidence (captures/100 trapnights or percentage of total catch) of albinism is rarely reported. As well, most references are of partial albinism or leucism, with few completely albino references. I can provide no plausible argument to suggest that albinistic individuals are not captured in proportion to their occurrence in the population.

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# Are Non-Native Gastropods a Threat to Endangered Lichens?

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Cameron, Robert. 2009. Are non-native gastropods a threat to endangered lichens? *Canadian Field-Naturalist* 123(2): 169–171.

Extensive grazing by gastropods was found on endangered Boreal Felt Lichen (*Erioderma pedicellatum*) at Sixth Lake, Nova Scotia, in 2004. At least 80% of arboreal gastropods observed at the site were the introduced species *Arion subfuscus*. Subsequent surveys at five other locations in Nova Scotia showed 90% of arboreal gastropod individuals observed were introduced species. Potential impact on native lichen species, and in particular on rare and endangered species, is discussed.

Key Words: Boreal Felt Lichen, *Erioderma pedicellatum*, gastropods, non-native, Nova Scotia.

*Erioderma pedicellatum* (Boreal Felt Lichen) is an epiphytic foliose lichen found in the temperate and boreal northern hemisphere. The world population of *E. pedicellatum* has been listed as critically endangered by the International Union for the Conservation of Nature. In Canada, the Atlantic population, occurring in Nova Scotia and New Brunswick, has been listed as endangered under the Canadian Species at Risk Act and provincially under the Nova Scotia Endangered Species Act. In Nova Scotia, the population declined by 90% between the early 1980s and the 1990s (Maass and Yetman 2002\*). Researchers have visited the known *E. pedicellatum* localities annually since 2004 to evaluate health and condition. There are 180 thalli in 30 locations known for Nova Scotia (Cameron et al. 2010).

During a re-visit to the Sixth Lake site (44°54'N, 62°43'W) in fall 2004, I found evidence of extensive grazing on the single *Erioderma pedicellatum* thallus at the site. Sixth Lake occurs on the eastern edge of the Tangier Grand Lake Protected Wilderness Area, Halifax County. About 60% of this thallus had been grazed and it appeared that about 80% of trees at the site harboured slugs on the trunks. *Arion subfuscus*, a non-native introduction from Europe, was the dominant arboreal slug found at the site at the time, making up about 80% of individuals found on trees. A voucher specimen was collected and will be deposited in the Nova Scotia Museum of Natural History. The only other species found was a native species, *Pallifera dorsalis*. Other lichen species with evidence of grazing included *Coccocarpia palmicola*, *Hypogymnia physodes* and *Parmelia squarrosa*. *Coccocarpia palmicola* is relatively uncommon in Nova Scotia (Cameron and Neily 2008), while *Hypogymnia physodes* and *Parmelia squarrosa* are very common (Casselman and Hill 1995; Cameron 2004; McMullin et al. 2008).

To help determine the magnitude of the potential threat to rare lichens from this introduced gastropod, subsequent surveys were conducted. Five mixed-wood forest sites in central Nova Scotia were surveyed for arboreal gastropods between 10 October 2005 and 3 September 2006. Locations of survey sites are Tangier Grand Lake Wilderness Area (44°53'N, 62°50'W),

Gully Lake Wilderness Area (44°33'N, 63°42'), Eigg Mountain-James River Wilderness Area (45°41'N, 62°10'W) and MacPhees Corner Hants County (45°07'N, 63°32'W) (2 sites). Site descriptions and location details can be found in Cameron et al. (2007) and Cameron and Richardson (2006). Sites were visited during days when gastropod activity was likely to be the highest, with daytime temperatures of greater than 10°C and an overcast sky with fog, drizzle or rain. One hundred trees (20 per site) of either *Acer rubrum* (Red Maple) or *Abies balsamea* (Balsam Fir) were examined for the presence of gastropods between the ground and 2 m up the trunk. Trees were selected for study by walking into the centre of the stand and choosing the closest trees of suitable species. Gastropod species (slugs and snails) were identified and, if they were actively feeding, the lichen species being grazed was also recorded. Identification of species was done using Burch (1962) and Burch and Jung (1988). There are several cryptic species of the *Arion fuscus/subfuscus* complex (Barr et al. 2009). However, since no collections of *Arion fuscus* in Nova Scotia had been reported in the literature up to Davis (1992), all species keyed to *Arion fuscus* or *A. subfuscus* were considered *A. subfuscus* for this study.

Twenty-one gastropods representing three slug species were found. No snails were found. Over 76% (16 of 21) of gastropods found were non-native *Arion subfuscus*. Four individuals (19%) were *Deroceras reticulatum*, also a non-native slug. Only one native gastropod species (*Pallifera dorsalis*) was found, and it was on *Acer rubrum*. *Arion subfuscus* was found more commonly on *Acer rubrum* (80% of findings) than on *Abies balsamea*. *Deroceras reticulatum* was found only on *Acer rubrum*. Species of lichens grazed included *Lobaria pulmonaria*, *Parmelia squarrosa*, *Parmelia sulcata* and *Platismatia glauca*. *Lobaria pulmonaria* is widespread and common in Nova Scotia (Anderson 2007), as are *Parmelia squarrosa* and *Platismatia glauca* (Casselman and Hill 1995; Cameron 2004; McMullin et al. 2008).

It is notable that 90% of arboreal gastropod individuals found were introduced species. Some caution is needed with this number because many native spe-

cies, which are much smaller than introduced species (Davis 1992), are more difficult to detect. Also, some species forage only at night or at very low light levels (Gauslaa et al. 2006). Nevertheless, under the investigated conditions, there appears to be a very high proportion of non-native arboreal gastropod foragers. Little is known about the distribution and abundance of terrestrial gastropods in Nova Scotia. However, Davis (1992) suggests that *Arion subfuscus* is common and widespread, having naturalized to mixed and deciduous forests. Davis and Browne (1996) suggest that non-native species, like *Arion subfuscus*, have restricted *Pallifera dorsalis* to native forests.

It is uncertain whether the non-native species are out-competing the native species or are filling a previously unfilled niche. The former seems more likely, since native arboreal foragers are present. Non-native gastropods can compete for resources or can prey on native species. Non-native terrestrial gastropod introductions have resulted in the decline of native species diversity and even the extinction of native species in other areas (Hadfield 1986; Proschwitz 1994; Mahtfeld 2000).

The impact of non-native gastropod grazers on native lichens is uncertain. Other studies suggest that lichens can recover from grazing by gastropods (Fröberg et al. 2006; Gauslaa et al. 2006). Asplund and Gauslaa (2008) indicate that grazing by molluscs may limit growth and early development of *Lobaria pulmonaria* in calcareous deciduous forest. However, previous studies have documented only the impacts of grazing by native gastropods. To my knowledge, this is the first documentation of non-native gastropod grazing on lichens.

No grazing animal was found on the *Erioderma pedicellatum* thallus at Sixth Lake. However, the pattern of grazing was indicative of gastropods (Sharnoff and Rosentreter 1998\*). The typical gastropod feeding tracks were quite wide, indicating a larger species like *Arion subfuscus*.

The disappearance of two thalli at another site, Jacket Lake (44°45'N, 62°42'W), may also have been caused by grazing. The Jacket Lake site is less than 2 km from the Sixth Lake site. The Jacket Lake site was visited in August 2006, when it was noted that two *Erioderma pedicellatum* thalli were healthy with minimal evidence of grazing. Researchers failed to locate two mature thalli on the same tree at the Jacket Lake site when it was revisited in March 2007. Careful examination of the locations on the tree where the thalli had been revealed small fragments of thalli that showed evidence of grazing. It could not be determined whether grazing was entirely responsible for the loss of these two thalli. It is, however, significant to note the rapid loss in less than 7 months of these two healthy thalli.

Cameron et al. (2009\*) found evidence of grazing on *Erioderma mollissimum*, another rare cyanolichen

found in Nova Scotia. Of 96 thalli observed between 2006 and 2008, 12 (13%) showed evidence of grazing. The area of the thalli grazed ranged from 1 to 20%. Most grazing had patterns typical of small invertebrates such as oribatid mites or Collembola. Only 3 thalli had grazing patterns typical of gastropods.

Further research is needed to determine the impact these non-native gastropod species may be having on native lichens and on rare and endangered lichens in particular.

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## Melanistic Tundra Voles, *Microtus oeconomus*, from Central Yukon

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Jung, Thomas S., David W. Nagorsen, and Lea A. Randall. 2009. Melanistic Tundra Voles, *Microtus oeconomus*, from central Yukon. *Canadian Field-Naturalist* 123(2): 171-172.

Colour aberrations are not commonly observed in voles (e.g., *Microtus* and *Myodes*); thus, individual observations are of interest. We report two observations of melanism in Tundra Voles, *Microtus oeconomus*, collected from central Yukon. These are the second and third records of melanistic Tundra Voles, and the first reports from non-insular populations.

Key Words: Tundra Vole, *Microtus oeconomus*, colour aberrations, melanism, Yukon.

Colour aberrations of voles are rarely observed; hence, individual observations are of interest (e.g., Owen and Shackelford 1942; Jewett 1955; Bowman and Curran 2000; Whitman 2009). Deviations from the normal agouti colouration of *Microtus* voles range from albinism to melanism, and include several intermediate variations (e.g., leucism, xanthochroism; Owen and Shackelford 1942; Pinter and Negus 1971; Stalling 1974). Here, we report two observations of rare aberrant coat colouration in free-ranging Tundra Voles (*Microtus oeconomus*) from central Yukon, Canada.

On 9 July 2005, we captured a melanistic Tundra Vole on Mount Turner (65.41°N, 136.28°W), approximately 212 km northeast of Dawson City, Yukon. The specimen was captured in a Museum Special trap (Woodstream Corp., Littitz, Pennsylvania, USA) and identified using morphological and dental characteristics. Overall, the fur of the vole was shiny black, rather than the greyish brown to yellowish brown of normally pigmented individuals, although the underparts and hair on the feet were slightly duller. The tail

did not appear bicoloured and the ears were also black. The vole, an adult female, was taken in a wet alpine creek bordered by a dense stand of willows (*Salix* spp.) and an understory dominated by *Equisetum* (horsetail). The specimen has been deposited at the Museum of Southwestern Biology (Field I.D.: NSY-005).

Using the ARCTOS database, we searched the collections of the University of Alaska Museum of the North (UAM; Fairbanks, Alaska) and the Museum of Southwestern Biology (MSB; Albuquerque, New Mexico) for Tundra Voles. A total of 7550 Tundra Vole specimens was located in the collections (5626 at UAM and 1924 at MSB), one of which was noted to be melanistic. On 15 July 1984, a melanistic adult male Tundra Vole (UAM 15762) was collected on Trapper Mountain (64.58°N, 138.22°W) in Tombstone Territorial Park, approximately 82 km northeast of Dawson City, Yukon. The skin of this vole was examined in the UAM collections and it was confirmed that it was uniformly black (B. Jacobsen, personal communication). This specimen was collected about 130 km

southwest of our specimen. No other species in the UAM collection were melanistic (B. Jacobsen, personal communication).

Several melanistic voles have been reported in the literature, specifically Meadow Vole, *Microtus pennsylvanicus* (Blossom 1942; Owen and Shackelford 1942); Common Vole, *Microtus arvalis* (Kocian and Ziak 1992); Montane Vole, *Microtus montanus* (Jewett 1955); and Prairie Vole, *Microtus ochrogaster* (Mumford 1964). Murie (1934) reported the only previously recorded melanistic Tundra Vole, from St. Lawrence Island, Alaska. He noted that there were local areas on the island where Aboriginal People indicated one could find other melanistic specimens, suggesting that some colonies had a propensity to produce melanistic individuals. Coat colour mutations have been noted in insular populations of free-ranging Meadow Voles (Parsons and Bondrup-Nielsen 1995), in captive populations of Montane Voles and Prairie Voles (Pinter and Negus 1971), and coat colour mutations may also occur in Tundra Voles (*sensu* Murie 1934). We are unaware of any occurrences of melanism in Tundra Voles other than that reported by Murie (1934). Thus, the two Yukon specimens constitute the second and third records of melanism in *Microtus oeconomus* and the first specimens from non-insular populations.

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# Effects of Hierarchy Rank on Caching Frequency in a Captive Coywolf (Eastern Coyote) *Canis latrans* × *lycaon*, Pack

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Way, Jonathan G., and Rebecca D. Cabral. 2009. Effects of hierarchy rank on caching frequency in a captive Coywolf (Eastern Coyote), *Canis latrans* × *lycaon*, pack. *Canadian Field-Naturalist* 123(2): 173–175.

Caching is useful because it ensures a consistent supply of food for animals. However, there is a relative paucity of data concerning which members of canid social units make the most caches. We provide data indicating that dominant members of a captive Coywolf “Eastern Coyote”, (*Canis latrans* × *lycaon*) pack did the majority (78%,  $n = 46$  of 59) of caching. Caching is a common activity stereotypically performed by canids, and dominant members of a social unit tend to cache more often.

Key Words: Coywolf, *Canis latrans* × *lycaon*, Eastern Coyote, *Canis latrans* var., caching, dominance, food burying, hierarchy, Massachusetts.

Caching is a behavioral adaptation which helps to ensure the availability of food during periods when prey is scarce. It is often performed by animals whose food abundance fluctuates (Sklepkevych and Montevocchi 1996; Mech 1997). Caching is done by a variety of animals, including spiders (Champion de Crespigny et al. 2001), rodents (Abbott and Quink 1970; Gates and Gates 1980; Rice-Oxley 1993; Busher 1996), birds (Dixon and Johnson 1997; Heinrich and Pepper 1998), and mammals (Smith and Reichman 1984), including carnivores (Ewer 1973). Specifically, for canids, caching has been documented in African Wild Dogs (*Lycaon pictus*) (Malcolm 1980); Gray Wolves (*Canis lupus*) (Harrington 1981; Mech et al. 1998; Mech and Adams 1999; Peterson and Ciucci 2003); Red Foxes (*Vulpes vulpes*) (Henry 1993); Arctic Foxes (*Alopex lagopus*) (Sklepkevych and Montevocchi 1996); and Coyotes (*Canis latrans*) (Knowlton et al. 1999).

Knowlton et al. (1999) noted that although caching may be common, it has only recently been described for Coyotes. Yet a review of the literature indicates that it has been reported more than previously recognized (e.g., Young and Jackson 1951: 91; Harrington 1982; Phillips et al. 1991; Windberg et al. 1997; Ellins 2005). There is, however, a relative lack of quantified data about which members of a canid social unit cache most frequently. Phillips et al. (1991: Figure 3) documented the dominant male Coyote in their study pack caching most frequently, while other studies have found that dominant individuals most often scent mark over food in both Wolves (Harrington 1981) and Coyotes (Harrington 1982). The objective of this paper is to provide data on the frequency of caching in a captive pack of “Eastern Coyotes” also called Coywolves, *Canis latrans* × *lycaon*: Way et al. 2010).

## Methods

Research was conducted on a litter of five captive “Eastern Coyotes” detailed previously (Way et al. 2006; Way 2007a). The animals were born 18–19 March 2002 in the wild, were taken into captivity at about three and a half weeks of age on 12 April, and were then socialized to JGW as they were raised for a behavioral and educational study. After three months of age, the Coyotes resided in a ~400 m<sup>2</sup> permanent exhibit at the Stone Zoo in Stoneham, Massachusetts. They were studied until the author was separated (by zoo staff) from the Coyotes in February 2005. Three of the Coyotes (male “Lupe” and females “Cane” and “Caon”) were observed for the entire study period, while the other two (male “Trans” and female “Late”) were observed for a year and a half until they were removed from the pack on 23 October 2003 due to intra-litter aggression (Way 2007a).

Although the Coyotes were hand-raised, JGW made no attempt to interfere with or discipline their activities and therefore gave the Coyotes free access, at all times, to their exhibit/living facilities. The Coyotes were provided with puppy milk (Esbilac, PetAg, Inc., Hampshire, Illinois) via bottle or bowl up until 15 May and were given access to water and dry dog chow (commercially available dog foods until March 2003, then Mazuri exotic canine chow/diet [PMI Nutrition International, LLC., Brentwood, Missouri] thereafter) at all times. They were group fed (i.e., all five at once) 0.75–1.6 kg (varying with their age) of Nebraska Brand chopped frozen canine meat (Central Nebraska Packing Co., North Platte, Nebraska) mixed with dog chow on a daily basis and were given frozen or thawed laboratory rats, guinea pigs, and mice (donated from a rodent breeding facility), and/or bones 2–4 times per week. Within their exhibit, the Coyotes commonly hunted (at least 1 prey item 2 or 3 times daily) and

TABLE 1. Captive Eastern Coyote names, maximum body mass (kg), gender, and pack dominance status from April 2002 to 23 October 2003 before Trans and Late were separated from the pack due to intra-litter aggression.

Name	Gender	Maximum weight (kg)	Intra-sex rank <sup>1</sup>	Overall rank <sup>2</sup>		
				20 April 2002 (33 days old)	19 July 2002 (123 days old)	13 to 14 August 2002 (149 days old)
Cane	F	20.5	1	2	2	3
Caon	F	17.3	2	3	4	4
Late	F	14.0	3 <sup>3</sup>	5	5	5 <sup>3</sup>
Lupe	M	26.0	1	1	1	1
Trans	M	17.7	2	4	3	2

<sup>1</sup>Rank for each gender.

<sup>2</sup>Overall rank within the pack. Pup age in days is denoted in parentheses.

<sup>3</sup>Late became tied for rank with Caon (4th overall and 2nd among females) from 10 March 2003 (age: 146 days) until 23 October 2003 (permanent separation of pack).

captured (about 1 or 2 prey items per week) Starlings (*Sturnus vulgaris*), House Sparrows (*Passer domesticus*), Eastern Chipmunks (*Tamias striatus*), Brown/Norway Rats (*Rattus norvegicus*), Meadow Voles (*Microtus pennsylvanicus*), and Gray Squirrels (*Sciurus carolinensis*), but did not eat much or any of these prey items.

We created an ethogram of Coyote behavior on standardized observation forms (Way et al. 2006) and also kept daily field notes. Data from this study were obtained by RDC reviewing JGWS notebooks and creating a detailed list of all instances of caching. To assess for dominance, we quantified dyadic interactions. We ranked the Coyotes and called the top-ranking male and female the dominant pack members, with the other three Coyotes referred to as non-dominant (Table 1), even though the second-ranked male was dominant over all three females for most of the study (after three months of age). A chi-square goodness-of-fit test was used to assess for the difference in caches between the two groups and to look at the difference of caching during summer (April–October) and winter (November–March) time periods. Significance was set at  $P < 0.05$ .

## Results and Discussion

We observed 58 bouts of caching, 42 of which (72.4%) occurred during summer and 16 (27.6%) during winter. One caching instance involved a double cache made by Cane, the dominant female of the pack (Table 1). Most caches were made by the two dominant members of the pack (Figure 1 – Lupe and Cane;  $n = 46$  of 59;  $\chi^2 = 18.5$ ,  $df = 1$ ,  $P < 0.0001$ ) with more made during both summer ( $n = 32$ ; Cane = 15, Lupe = 17;  $\chi^2 = 11.5$ ,  $df = 1$ ,  $P = 0.0007$ ) and winter time periods (Cane = 8, Lupe = 6;  $\chi^2 = 7.1$ ,  $df = 1$ ,  $P = 0.008$ ).

Caching Coyotes typically took an object to a fairly hidden part of their exhibit, often traveling in zigzag patterns before selecting a caching location. Individuals then created a small hole by digging up substrate (e.g., dirt, snow, leaves, gravel) with backward movements (i.e., toward their body) of their front legs/paws,

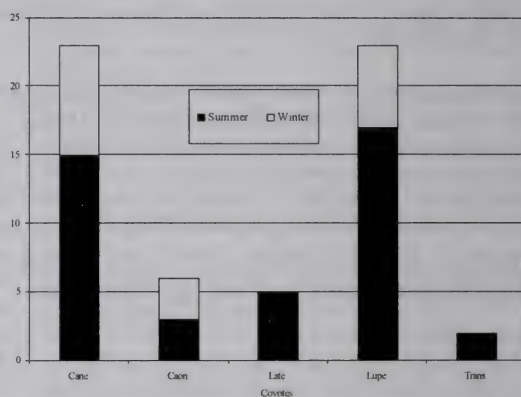


FIGURE 1. Winter (November–March) and summer (April–October) caching events by female (Cane, Caon, Late) and male (Lupe, Trans) Coyotes. Note: Cane and Lupe were dominant members of their sex.

usually with the object to be cached in the mouth (see methods), then deposited the object in the depression that they had dug, using their snout to press the food into the hole (i.e., tamping). They then covered the object with forward motions of their nose (“scooping”—Phillips et al. 1990, 1991) using the substrate that had been dug up (e.g., dirt, sand, or snow).

This observed caching sequence in Eastern Coyotes (Way 2007b; Way et al. 2010) is similar to that described by Phillips et al. (1991) for Coyotes, by Henry (1986: 95, 1993: 76) for Red Foxes, and by Mech (1970: 190, 1997: 121–122), Murie (1944: 60), and Phillips et al. (1990) for Wolves. Caching appeared to be stereotypical and instinctual (as they were raised by JGW and not adult Coyotes) that was perfected with practice (see Henry 1986: 99–101; Phillips et al. 1990, 1991).

Although this study was hampered by a small sample size, common to many captive studies of carnivores, our results suggest that the dominant members of a canid social group make a large proportion of caches.



Dominant Coyotes usually have access to more resources (Gese et al. 1996a, 1996b), and the confined nature of a zoo-like setting likely facilitated competitive interactions (especially between the three females) and subsequent caches when the dominant Coyotes were full. The relatively small size of the exhibit no doubt allowed other Coyotes to locate those caches easily. In the wild, however, Coyotes would likely travel greater distances to hide their food, similar to that described by Mech and Adams (1999) for Wolves. Furthermore, wintertime caching did not appear to differ from non-wintertime caching in form or function, with the exception of snow and ice often being present, and with the overall frequency of caches being less than during summer.

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# Dragonflies (Odonata) Emerging from Brackish Pools in Saltmarshes of Gaspé, Quebec

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Catling, Paul M. 2009. Dragonflies (Odonata) emerging from brackish pools in saltmarshes of Gaspé, Quebec. *Canadian Field-Naturalist* 123(2): 176–177.

*Enallagma hageni*, *Lestes disjunctus*, *Sympetrum costiferum*, *Sympetrum danae*, *Sympetrum internum*, and *Sympetrum obtrusum* were observed emerging from brackish pools with an overall salinity range of 6.0–17.3 ppt in three saltmarshes in Gaspé, Quebec. *Lestes congener*, *Libellula quadrimaculata*, and species of *Sympetrum* were prominent among the larvae in these pools.

**Key Words:** *Lestes congener*, *Libellula quadrimaculata*, *Sympetrum danae*, Odonata, dragonflies, saltmarsh, salinity, Gaspé, Baie des Chaleurs, Quebec.

A recent study (Catling et al. 2006) has shown that saltmarshes are used much more extensively by dragonflies than was previously thought and that the saltmarshes of the Baie des Chaleurs region of Quebec and New Brunswick possess a diverse and distinctive dragonfly fauna. The locations and dominance of restricted saltmarsh flora at the sites included in that study left no doubt that the habitat was brackish, and the observations of emergence, presence of larvae, and large numbers of adults left no doubt as to the utilization of this brackish habitat. However, two of the predominant species, *Lestes congener* and *Sympetrum danae*, were not shown definitely to develop in brackish pools. Here presence of larvae and emergence of these and other species from pools of measured salinity are reported.

## Methods

Observations of emergence were made and larvae were collected from saltmarsh pools at three sites (Table 1) in the Gaspé from 16 to 18 July 2009. At all of the sites, the pools were mostly less than 10 cm deep but up to 30 cm in the deepest parts and had surrounding and emergent vegetation dominated by *Carex paleacea* Schreber ex Wahlenb., *Juncus* spp., and *Scirpus* spp. The bottoms were organic with an incomplete cover of *Chara* sp., *Ruppia maritima* L., and *Potamogeton pectinatus* L., all of which were confined to patches of deeper water. Salinity was measured with a Pinpoint salinity monitor based on electronic conductance, and the values were converted to

TABLE 2. Species of dragonflies emerging and recorded as larvae from saltmarsh pools at three saltmarshes in the Gaspé.

Species	Site		
	1	2	3
<b>Emerging</b>			
<i>Enallagma hageni</i> (Walsh)	1	—	2
<i>Lestes disjunctus</i> Sélys	1	—	—
<i>Sympetrum costiferum</i> (Hagen)	—	1	—
<i>Sympetrum danae</i> (Sulzer)	2	13	—
<i>Sympetrum internum</i> Montgomery	5	7	3
<i>Sympetrum obtrusum</i> (Hagen)	1	5	—
<b>Larvae and Exuviae</b>			
<i>Aeshna</i> cf. <i>interrupta</i> Walker	1	—	—
<i>Aeshna</i> cf. <i>umbrosa</i> Walker	1	—	—
<i>Enallagma</i> sp.	1	—	—
<i>Lestes congener</i> Hagen	6	—	—
<i>Lestes</i> sp.	1	—	—
<i>Libellula quadrimaculata</i> Linnaeus	12	3	—
<i>Sympetrum</i> sp. (cf. <i>danae</i> or <i>internum</i> )	11	9	9

ppt. Identifications of Odonata were made using Walker (1953, 1958) and Walker and Corbet (1975). Voucher specimens are deposited in National Collection at Agriculture and Agri-Food Canada in Ottawa (CNC).

## Results and Discussion

Six species, including *Enallagma hageni*, *Lestes disjunctus*, *Sympetrum costiferum*, *Sympetrum danae*, *Sympetrum internum*, and *Sympetrum obtrusum*, were observed emerging from brackish pools with an overall salinity range of 6.0–17.3 ppt (Tables 1 and 2). *Libel-*

TABLE 1. Names, locations, and salinity range of pools examined in four saltmarshes on the coast of Gaspé.

No.	Name	Location	Salinity range (ppt)
1	Barachois de Malbaie saltmarsh	48.5829 N, -64.3015 W	8.1–11.0
2	Baie au Chêne saltmarsh	48.0508 N, -66.6512 W	6.0–8.8
3	Pointe-à-la-Garde saltmarsh	48.0754 N, -66.5430 W	16.3–17.3



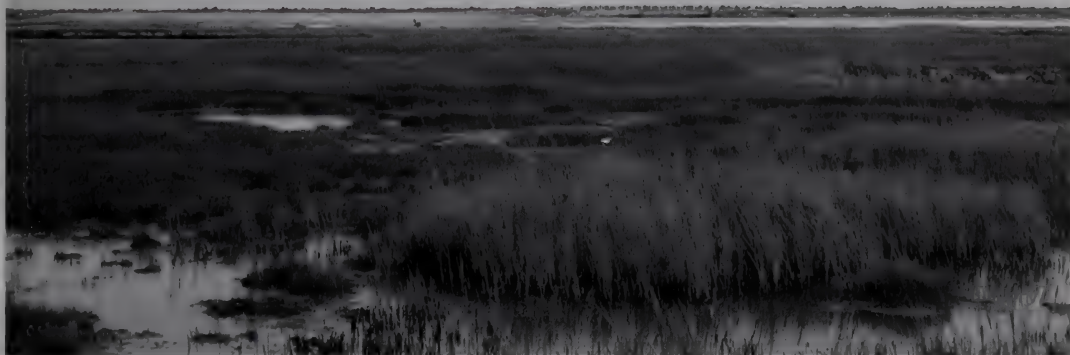


FIGURE 1. Shallow brackish (8.1–11.0 ppt) pools with water to 5 cm deep and lacking submerged vegetation in the Barachois de Malbaie saltmarsh, where *Sympetrum danae* and *S. internum* were emerging and larvae of *Lestes congener* were present in the pool in the foreground on 17 July 2008. Photo by P. M. Catling.

*lula quadrimaculata* and *Sympetrum* sp. were well represented among the larvae from the three sites (Table 2). Larvae of *Sympetrum* could not be determined with confidence, but most appeared referable to *S. danae* or *S. internum*. Several larvae of *Lestes congener* found in ponds with salinity ranging from 8.1 to 11.0 ppt were notable and provide support for the suggestion that this species is a resident of saltmarshes in the area (Catling et al. 2006). Other larvae found in the brackish pools included *Aeshna* cf. *interrupta* Walker, *Aeshna* cf. *umbrosa* Walker, *Enallagma* sp., and *Lestes* sp. (Table 1).

All of the species noted above were expected, based on abundance of adults in saltmarshes in the region (Catling et al. 2006), but these observations are of particular interest because they confirm that *Lestes congener*, *L. disjunctus*, *Libellula quadrimaculata*, *Sympetrum danae*, and *S. obtrusum* develop in brackish ponds. The observations also provide additional support for use of brackish ponds by the species for which larval records already exist.

Although a comparison of the habitats within pools was beyond the scope of this study, it was noticed that *Libellula quadrimaculata* larvae were confined to deep-

er pools with more submerged vegetation, whereas larvae of *Sympetrum* and especially emerging *Sympetrum danae* came from pools less than 10 cm deep with emergent but no submerged vegetation (e.g., Figure 1).

### Acknowledgements

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# Persistence of a Reintroduced Fisher, *Martes pennanti*, Population in Cooking Lake-Blackfoot Provincial Recreation Area, Central Alberta

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Proulx, Gilbert, and Brian Genereux. 2009. Persistence of a reintroduced Fisher, *Martes pennanti*, population in Cooking Lake-Blackfoot Provincial Recreation Area, central Alberta. *Canadian Field-Naturalist* 123(2): 178–181.

In order to confirm the persistence of a Fisher (*Martes pennanti*) population reintroduced in 1990 in Cooking Lake-Blackfoot Provincial Recreation Area, central Alberta, we inventoried trails in the winters of 2006 and 2007. We recorded the presence of Fishers in 16 locations, and we confirmed the presence of at least two animals. We believe that the presence of Fishers 17 years after their release in the recreation area indicates that there is a self-sustaining population.

**Key Words:** Fisher, *Martes pennanti*, Parklands, reintroduction, Alberta.

Habitat loss, unregulated trapping, and predator control significantly reduced or eliminated Fisher (*Martes pennanti*) populations in south-central Alberta by the mid-1980s (Douglas and Strickland 1987; Alberta Fish and Wildlife Division 1989\*). In an effort to re-establish Fisher populations in the central parklands of Alberta, Proulx et al. (1994) reintroduced 20 Fishers in 1990 and monitored them using radio-telemetry until 1992 (Badry et al. 1997). The success of a reintroduction program should be measured not only by the successful release of individuals but also by the ability of those animals to reproduce successfully and create a self-sustaining population post-reintroduction. Some authors suggest that a reintroduced population should persist for 10 years for the program to be termed a success (Hayward et al. 2007; Muths and Dreitz 2008). In the early 1990s, the reintroduced Fishers settled in the vicinity of their release sites (Proulx et al. 1994) and reproduced (Proulx et al. 2004). However, no inventory occurred in the release area since 1993 to confirm the persistence of the reintroduced Fisher population. The objective of this study was to document the winter distribution of Fishers in the Cooking Lake-Blackfoot Provincial Recreation Area in central Alberta.

## Study Area and Methods

The Cooking Lake-Blackfoot Provincial Recreation Area (53°32'N, 112°47'W) is a 97 km<sup>2</sup> natural area located south of Elk Island National Park, approximately 40 km east of the city of Edmonton, Alberta (Figure 1). The region is part of the central parklands that consist of open grassland alternating with groves. The groves were composed of mainly Quaking Aspen (*Populus tremuloides*) with Balsam Poplar (*Populus balsamifera*), willows (*Salix* spp.), Paper Birch (*Betula papyrifera*), and White Spruce (*Picea glauca*) (Hardy Associates Ltd. 1986\*; Looman and Best 1987).

In the winters of 2006 and 2007 from January to March 2006 and November 2006 to February 2007 we repeatedly inventoried 20 trails by snowshoe (a total of 136 km over two years) that crossed areas where the Fishers had been released in the 1990s. We recorded only well-defined tracks, those not melted or deformed,

and not filled with snow. We used the combination of footprint (pattern and size, presence/absence of toe pad prints) and trail (gait, distance between jumps, and dragging of the feet) characteristics to identify all tracks (Murie 1975; Rezendes 1992; Halfpenny et al. 1995). Fishers' foot pads have sparse hair, and they show well in clear prints (Halfpenny et al. 1995). Fishers tend to create a trough when walking in soft snow, drag their feet, and leave tail drag-marks in the snow (de Vos 1951; Raine 1983).

## Results and Discussion

Fisher tracks were recorded at 16 locations along trails (Figures 1 and 2). We were not able to determine whether tracks found during different inventories within the same portion of the study area belonged to the same animal because home ranges may overlap (Badry et al. 1997; Weir 2003\*) and winter dispersal movements are known to occur (Arthur et al. 1993). On the other hand, under ideal snow conditions on the same day, we were able to identify two different series of Fisher tracks that were 2 km apart: one with 5-cm-wide tracks, and another with ≥ 6.5-cm-wide tracks. Fishers appeared to use the north-central portion of the study area. All tracks were found in deciduous forests, as has been reported by Badry et al. (1997).

This study confirmed the presence of Fishers 17 years after their release in the study area. The Fisher population in the Cooking Lake-Blackfoot Provincial Recreation Area is well removed (> 150 km) from Fisher populations inhabiting boreal forests (Figure 1; Proulx et al. 2004), and immigration is very unlikely (Badry et al. 1997). The area is surrounded by agricultural fields, and the survival of animals dispersing from northern forests through open fields would be low (Proulx et al. 1994). In the last 17 years, Fisher sightings and signs have been reported in the vicinity of the Cooking Lake-Blackfoot Provincial Recreation Area (Dekker 2005; Proulx, unpublished data). A young Fisher was captured in a Beaver (*Castor canadensis*) trap within the recreation area in 1993. This study confirmed the presence of Fishers in habitats where animals had been released in the early 1990s. All this



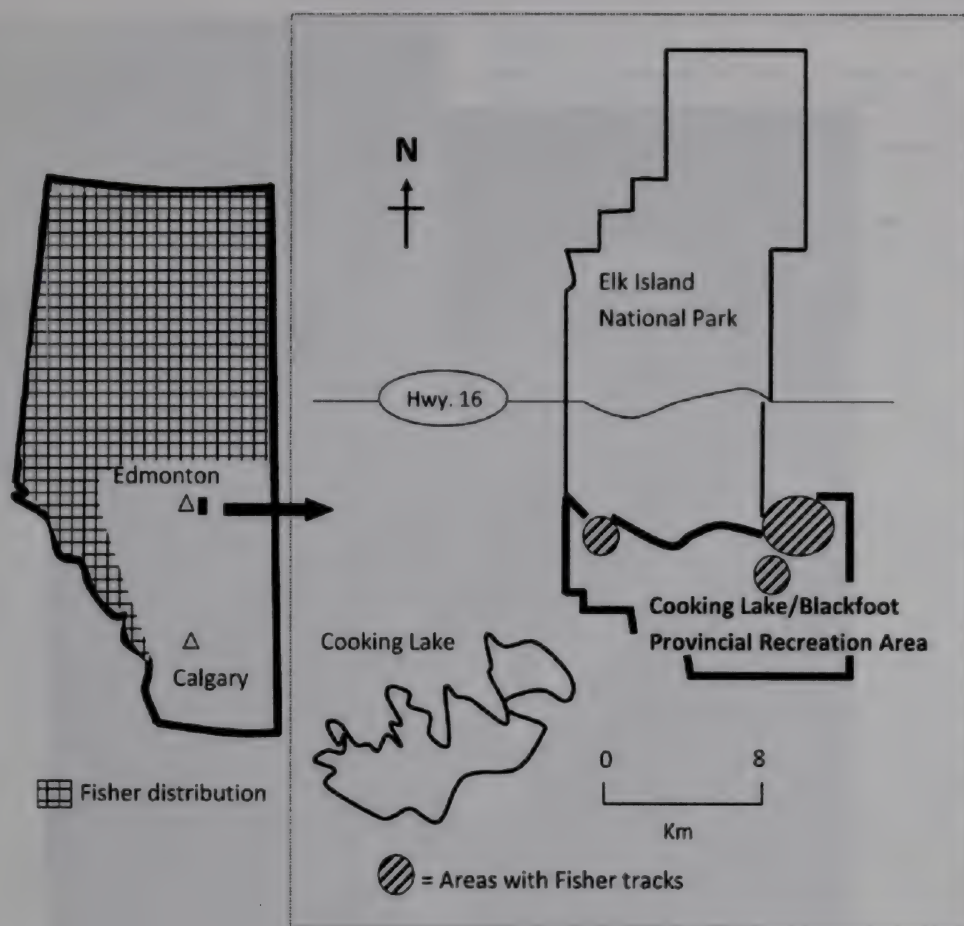


FIGURE 1. Distribution of Fisher in Alberta (after Proulx et al. 2004) and in Cooking Lake-Blackfoot Provincial Recreation Area, winters of 2006 and 2007.

evidence leads us to believe that the presence of Fishers in the Cooking Lake-Blackfoot Provincial Recreation Area is the result of reproduction, which suggests that the population is self-sustaining.

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FIGURE 2. Fisher tracks recorded in Cooking Lake-Blackfoot Provincial Recreation Area: (a) footprint, and (b) 2-2 running pattern.



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## Book Reviews

**Book Review Editor's Note:** We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars are AUD and so on.

### **Birds of Borneo, Brunei, Sabah, Sarawak, and Kalimantan**

By Susan Meyers. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 08540. 272 pages., 29.95 USD Paper.

At 750 000 km<sup>2</sup>, and somewhat larger than Saskatchewan, Borneo is the third largest island in the world. It has about 16 million socially diverse people living in parts of three countries – Indonesia [the provinces of East, South, West and Central Kalimantan], Malaya [the states of Sabah and Sarawak] and Brunei. It is surrounded by Malay Peninsula and Sumatra, Java, Sulawesi (Celebes) and the Philippines. In this relatively small space is crammed about 18 000 species of plants, over 200 species of mammals, and 630 species of birds. This diversity fills seven ecoregions.

In her book the author covers 633 species [430 resident], including an amazing 50 endemics. These range from the tiny enclave of House Crows that have recently arrived to the common and widespread Spotted Fantail. Borneo has some truly colourful birds. The flycatchers are not brown like ours but vibrant blue, orange yellow or red. The ten species of pitta [about the size of a short-tailed Phoebe] are even more multi-coloured. And the list goes on; minivets, sunbirds, orioles, leafbirds, kingfishers and trogons.

I thought 50 was high for number of endemics; 30 seemed more reasonable. The author has achieved this by including all the sub-species that are regarded as full species by some authorities, but not by others. So the Bornean Peacock-Pheasant is split from Malaysian Peacock-pheasant, the Bornean Bulbul from the Black-crested, the Pale-faced from the Flavescent Bulbul and so on. She also includes the Blue-banded Pitta which some references give a larger distribution than Borneo while others agree it is an endemic.

I was recently told the way to lose your hair was to edit a book that has multiple authors. I wonder if that holds for a book that has multiple artists? This book has contributions from 16 artists. Most of these people worked on Craig Robson's *A Guide to the Birds of Southeast Asia* [Also published by Princeton]. Indeed many of the illustrations have been recycled from that

publication. Nonetheless the illustrations are good. I have a few minor comments. I thought that the juvenile Chinese Sparrowhawk's belly barring was not defined enough, the Black Duck's facial pattern was a bit too strong and the spatulate tail of the Pomerine Jaeger did not show well.

For birders in Borneo, this is a good and useful book. The information given in the text is well-organised and gives all you need in a field guide. The range maps are easy to interpret. Rare vagrants, even if it is a single record, are included in the main text with the same detail as more common birds. I would have preferred the terms endemic and endangered to have been in red so they were more visible. Also the author does discuss "Similar species", but this section is a bit limited at times. There are several groups of look-alike birds for which a visiting birder could do with some extra help. I agree with Myers, though, when she discusses "Similar species" under snipe; she says "plumage differences have been overstated."

Sadly, there are two problems that mar this book's introduction. The illustration for Bornean Barbet is an incorrect repeat of the similar Blue-eared Barbet. The Temminck's Babbler is a repeat of the Abbots Babbler. This is most unlike this publisher and they have supplied an insert with the correct illustrations.

I have the paperback version that is missing the visual index and maps included in the cloth edition. These can be printed off the Princeton website should you choose to do so. I decided not to bother – at least at this time.

This is a great buy for the travelling birder and it will encourage people to take one of the many tours now being offered. Locals will also find it useful as, like many of the new Princeton guides, it is compact and light and easy to carry over difficult terrain.

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## Resource Insects of China

By Chen Xiaoming, Feng Ying. Science Press, Beijing, China, 2009. 281 pages, Price: 56.00 CNY

Insects belong to the Insecta in the Arthropoda and are an ancient biological taxa. The earliest fossil of insects are found in the Late Paleozoic of the Devonian, about 3.5-4 million years ago. The survival and development of insects began about 3.4 billion years earlier than that of humans on earth. According to the report of the Department of insects of the British Natural History Museum, presently, there are more than 10 million insect species in the world, in which about 0.9-1.3 million insect species have been described. Furthermore, the number of insects increases at an average rate of 7000 species per year. In the long evolutionary process, insects have developed some prominent biological characteristics, such as short generation period, rapid reproduction rate, high adaptability, high food conversion rate and so on. It is estimated that the total biomass of insects is more than that of all the other animals on earth. The number of species of insects accounts for about half of all living organisms on earth, and accounts for more than 80% of all animals, being the largest component, not only of the animal kingdom, but of all life on the earth. Insects are the most widely distributed animals in the world, being able to live in almost every corner of the earth.

Many insect species on the one hand can damage crops and decrease agricultural production, but on the other hand are useful to humans. Resource insects refer to the insect products (secretions, inclusions and excreta, etc.) or insect behavior or insect body itself have special values or can be directly or indirectly used as resources by humans, due to their special values of use either in the economy or in science and environment. Resource insects include the industrial-raw-material insects, silk-production insect, honey-production insects, worm-tea-production insect, medicinal insects, edible insect (food or feed insects), pollination insects, ornamental insects or cultural insects, environmental friendly insects, insect as natural enemies of pest and so on. The resource insects can be applied in many fields, such as chemical industry, national defence industry, electronics, clothing, food, medicine, agriculture, forestry, environmental protection and national culture and so on. Many insects are rich in protein, fats, carbohydrates, free amino acids, vitamin, carotene, inorganic substances such as various salts, potassium, sodium, phosphorus, iron, calcium and some active substances with medicinal values that human body needs, thus, there is high values of exploitation and use. The insect world is a vast reservoir of resources, and is an important renewable biological resources. Insect resources are the last piece of cake that the God left us. However, how to efficiently and sustainably use these still needs detailed exploration.

China is the only country across two geographical regions of animals in the world, and the one with the largest number of insect species, and longest history of use of insect resources, in the world. Therefore, recognition, exploitation and use of insect resources is of particular importance in China, and needs in-depth research. The number of insect species in China is about  $\frac{1}{10}$  of total number of species of insects in the world with, more than 30 000 recorded. There are 145 species of medicinal insects in China according to the Chinese medicinal animal records. Since insects contain a variety of active substances, they have been used as high value of traditional Chinese medicine resources for a long history. The famous *Compendium of Materia Medica* in the Ming Dynasty and the modern Chinese medicine books record 11 orders, 34 families, 54 genus, and about 170 species of medicinal insects, including the poisonous insects. Chinese ancestors used silkworm for more than 5000 years. The history of bee-keeping in China is more than 3000 years. The records on Chinese gall can be traced back 2000 years ago in the ancient book *Shanhai Jing*. The history of the use of wax worms is more than 1700 years. Wax insects have been nurtured and utilized by Chinese about 1000 years. Use of a natural enemy to control a pest in China dates to 340 A.D. More than 400 ornamental insect species have long been used in China.

Although China has a long history of use of resource insects in the world, knowledge about them has not been systematically summarised and new research on this field remained inadequate for a long time. To some extent, this has limited fast and efficient development of this field in China. Luckily, the newly published book *Resource Insects of China* is a new landmark that meets the demands of vast numbers of Chinese people who are interested in resource insects by filling the gap in this field in China. Besides that, it is a good introduction to Chinese resource insects for the outside world.

Many researchers have carried out study on lac insect, wax worms, gallic aphids, cochineal, edible insects, medicinal insects, ornamental insects, insects as natural enemies of pests, pollination insects, and the insect cell engineering and so on, since 1950s. The abundant research data on which the authors based this monograph combines the latest achievements of domestic and foreign research in this field with their own research results. The book systematically elucidates the main characteristics, scientific values, and application values of the resource insects of China.

The book is divided into 16 chapters, including introduction, lac insects, wax worms, gallic aphids,

cochineal, silk insects, honey insects, medicinal insects, insects as protein resource, insects as natural enemies of pests, pollination insects, ornamental insects, environmental friendly insects, scientific value and application of insect cells, bio-reactor of insects, special abilities and bionic insects and so on. Each chapter introduces a large number of examples of specific types of insects and their biological and ecological characteristics, application values, research status at present, and the developmental trends, based on domestic and foreign research data or references. Both pictures and text are good enough. The book is a systematic monograph on the insect resources of China, especially the latest information on the resource entomological research.

## Mammals of India

By Vivek Menon. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 208 pages, 35.00 USD Paper.

*The Book of Indian Mammals* by Prater [The Bombay Natural History Society] is, despite updates, a 60-year-old book. The information is still valid, but the style is antiquated. The illustrations, by Paul Barrel, are excellent. However it is long past time for a new book. Vivek Menon's contribution is, therefore, most welcome.

The author provides full coverage [though not necessarily with an illustration] of just over 250 species of India's 400 or so mammal species. Some less frequently seen species get partial coverage, often as part of a comparison table.

There is an introduction to each family followed by a species account for most of the mammals you could see without going to unusual lengths [such as setting traps]. Each account covers a description, notes on behaviour, size and habitat. He gives the various local names too. The author also adds the places where you are most likely see the animal. Names are given in English and several Indian languages. The tiny range map shows its current distribution. A text box gives a quick reference to essential data [Scientific name, status, an estimate of the current population, diet, social unit, the time it is active and where you might find it]. All the species covered are illustrated by photographs, except the cetaceans. Key characteristics are highlighted by lines and appropriate text. There is a broader coverage than Prater's book, with more small mammals [mice, bats shrews etc.] included. The author does not cover sub-species.

The visitor to India will find this a very useful book for all the larger mammals. You will be able to identify similar species like Bonnet and Rhesus Macaque. You will have no difficulty identifying the common Sambar deer from the scarce Swamp deer. Small mammals,

This book will provide a valuable reference or teaching material for those engaged in teaching, technical or research work in entomology, agriculture, forestry, ecology, biology, environmental sciences and so on, or other persons who are interested in these fields.

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like mice and rats, will be more difficult, but that is not the fault of the book. For example, you should be able to separate and identify the striped squirrels. However I was not able to finalise the identity of a [*Rhinolophus*] horseshoe bat I photographed last year.

It is the larger, diurnal species that most people will see. The Gaur, for example, has a clear photo that shows its size, chocolate brown body and characteristic white "socks." The text tells you there are 20 000 left in a declining population and it is most easily seen at Mudumalai and Bandipur National Parks. The following entry for Yak notes there are less than 100 wild Yaks left in the Chang Chen Mo valley in Ladakh [10 000 in the world, compared to 14 million domestic Yaks].

Most people will focus on seeing a Tiger – a really magnificent beast. The national parks system is well organized to find a Tiger for visitors to see. The book recommends Rathambhor and Bandhavgarh parks, both excellent choices. Oddly, there are five times as many Leopards as Tigers, but the former are more difficult to see. Most of the other cats are confined to discrete portions of the Himalayas.

This is an excellent and much needed modern guide. It might not be detailed enough for a serious researcher, but it is great for the visitor. It is easy to use, with a lot of quality information packed into a book that only measures 21.5 × 14 × 1 cm. The only "negative" comment I can make is that so many of the population figures are followed by "declining." In the conservation note, habitat loss and poaching are the dominant factors. It is sad to think that the beautiful, fascinating animals in this book could disappear from India's wonderful heritage. Buy the book and visit India soon.

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## The Migration of Birds: Seasons on the Wing

By Janice M. Hughes. 2009. Firefly Books Ltd., Richmond Hill, Ontario. \$40.00, 207 pages.

"Birds travel because they must, they go because they wish to, and they journey because they can" – a neat description of bird migration by the author. If you are looking for a book for a birdwatcher friend, consider this one. It summarizes what is known today about migration and how that knowledge was accumulated. The author prepares the ground by first giving the history of what is known about the evolution of birds and the archaeological finds. She covers the science of flight, ancient legends, "hibernation" (particularly that old myth of hibernating swallows, postulated first by Aristotle and not laid to rest – reluctantly – until the 19<sup>th</sup> century), and the early printed books which speculated on why birds migrate. One was a book by Linnaeus in 1757 entitled *Bird Migration*, another was by Gilbert White.

It has been a long, slow search to plot migration routes, to map wintering and breeding grounds, and the different paths used are well described and illustrated. As technology has advanced in the fields of climatology and telecommunications, so has knowledge about migration. A new hazard for some birds on migration is that with the warming climate, flower and insect food peaks and have completed their cycles before the migrating birds arrive at their nesting grounds.

In the laboratory, scientists have analyzed the hormonal changes which trigger migration and the subsequent minute changes in the bird brain. These changes also initiate accelerated weight gain needed to sustain the bird's body on long flights. "Bird brain" as a taunt is a misnomer, since in fact these small brains are complex – among other substances, they contain magnetic crystals, a compass, and memory. The tiny crystals are magnetite, a type of iron ore. It is now well known that direction-finding on migration depends primarily on the geomagnetic fields of the earth which are relayed to the bird brain. Solar and stellar positions as internal compasses are secondary aids to navigation

and all three methods help a bird to plot origin, stop-over, and destination positions and to follow a strict path, with one or other of the three used to recalibrate direction when the bird goes off course.

Another, less important, aid to navigation is provided by some long wavelength infrasounds generated in the jet stream which create landmarks audible to migratory birds. Homing pigeons have been important laboratory subjects in providing scientific knowledge about migration because their navigation instincts have been heightened by the selective breeding of pigeon fanciers. Carrier pigeons were used by Genghis Khan, Charlemagne, Reuters, and even modern armies to carry messages. Memory also plays a role in navigation. Many bird species have demonstrated memory such as Blue Jays and Clark's Nutcracker which cache food and remember their larders. Some birds have shown evidence of genetic memory – a Whooping Crane which was born and spent its life in Florida was transported in spring to Manitoba (by plane), released there and returned alone to its birth place in the fall.

The author discusses the hazards of migration – loss of staging grounds, collisions with office buildings and communication towers, predation by cats, and adverse weather. There are excellent and helpful two-page profiles of some individual migratory species which include: Chinese cranes, Phalaropes, Shrikes, Arctic Terns, Wheatears, Dippers, and birds of prey. These individual accounts describe in detail the life story and particular migration of that species and include a map showing its breeding, wintering grounds and the migration routes.

Throughout the book there are excellent photographs, and illustrations of radar tracking – a credit to the Chinese printers. There is a glossary, a general index and a species index but, unusually, there is no information about the author.

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## A Photographic Guide to Seashore Life in the North Atlantic – Canada to Cape Cod

By J. D. Sept. 2008. Princeton University Press, 41 William Street, Princeton, New Jersey 08540. 224 pages, 19.95 USD Paper.

I have long believed that a real naturalist is interested in all life. Some of my birder friends refer to the plants that birds perch on as "green stuff." I think that such an attitude is a sad loss because there are many wonderful, non-avian things to see on this earth. There are a lot of top quality choices for books on birds, plants and mammals. There is a more modest choice for reptiles, butterflies and dragonflies. There is not much available however on seashore life so any

book is welcome. Sept's guide covers most of the common species found on rocky shores, sandy shores, mud beaches, and floating docks.

This guide covers a wide range of organisms from worms, jellies and sea anemones, through clams and crabs, to seaweeds, lichens and seashore plants. Indeed the author portrays examples from 15 phyla. With the introductory section it is a Course 101 for shore life. Each species is illustrated with high quality, clear

photographs, supported with well-written text. The author often uses the correct scientific term but adds a simple explanation in parentheses [phycoerythrin (algal red pigment)] making the text easy to follow.

This book brings back memories of many old "friends." The Moon Jellies and Beroe's Comb Jellies I saw floating off shore, the limpets, sea-snails and whelks in the tide pools and the Knotted Wrack cascading off the rocks. It reminded me of one of the most fascinating presentations I ever experienced. It was an explanation of the sex life of seaweed given in a swirling rock pool just behind the Peggy's Cove lighthouse. While the author does not give this complex story *per se* there are hints in some of the algae accounts.

The book includes about 225 common species. I estimate that if you walked for an hour along a typical Nova Scotia beach you could find 20 to 30 species with ease. As the book is only 21.5 × 14 × 1.5 cm it would be easy to carry along. For the Common Periwinkle [a very tasty little beast] the photographs give a good sense of size, colour, shape and variability. These are easy to compare with the those of the Smooth and Rough Periwinkle. Nearby you might find a beige "seaweed" made of felt. Look up Leafy Bryozoan. Push through the wrack and you will likely find a few scud, little shrimp-like critters. Keep going and you will surely find some young Rock Crabs or one of the

hermit crabs. Now I have an urge to get to a beach and try poking around with this book in hand. The trouble is I am off to the Pacific next.

The author gives a brief overview of various intertidal habitats, such as sand beaches, mud flats, rocky shores and other micro-habitats. He also includes a guide to the best places in Nova Scotia, Prince Edward Island, New Brunswick, Newfoundland, and Labrador, Maine, New Hampshire and Massachusetts. While the locations given are very good almost anywhere along the coast will have a good range of species.

As much as I enjoyed this book, there is one disappointment. The author did not include any plankton. The zooplankton from the Bay of Fundy are among the most beautiful creatures on earth. Surely some one can buy one of the new digital microscopes and create a book on this neglected part of wildlife.

For \$20 this book is a great buy. Useful and useable, it will be an asset to any naturalist who wants to understand shore life in full. Better yet take a child along and get them interested – tidal pool creatures are easier to observe than flying birds or diving mammals.

A visit to Sept's website at <http://www.septphoto.com> is also worth the effort.

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## Turtles of the United States and Canada

By Carl H. Ernst and Jeffrey E. Lovich. 2009. Second edition. Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363. 827 pages. 95 USD.

The first edition of *Turtles of the United States and Canada* by Carl Ernst, Jeffrey Lovich, and the late Roger Barbour was published in 1994. With its detailed species accounts it became the definitive reference on the turtles of North America. Is this new edition required? Absolutely. The first edition cited approximately 3000 publications on turtles, while this new edition references more than 5000 – an indication of the explosion in scientific research on turtles in the last 15 years.

The format is almost identical to the previous edition. One change is that each species account begins with an introductory paragraph, putting the species into context. Information on the species is then provided in the following categories: Recognition, Karotype, Fossil Record, Distribution, Geographic Variation, Confusing Species, Habitat, Behavior, Reproduction, Growth and Longevity, Diet and Feeding Behavior, Predators and Defence, Populations, and Remarks. Each species account is accompanied by a shaded distribution map and colour photos of each species (generally one shot in nature, one of the plastron and

one of a hatchling). One unfortunate change to the new edition is that species accounts no longer always start on a new page. The species accounts within a given genus begin immediately after the previous species account ends. One change not made from the last edition is the content of the index, which is only indexed on the names of the turtles. Want to know which species have been reported killed by boat propellers or have experienced necrotic shell diseases? Good luck. You'll have to read the population section of every species account.

Any volume attempting to summarize such a huge amount of scientific literature is bound to include some errors. There are enough careless errors to make one want to double check any unlikely "facts" in the book. For example, it is stated that a Snapping Turtle died of *hypothermia* before nesting, when it should be *hyperthermia* (page 117). The authors also claim (without any supporting reference) that the diminutive Spotted Turtle can lay up to 14 eggs (page 218). I can find no evidence of a Spotted Turtle laying more than 7 eggs and the average is much below this. I may be



biased in my opinion of the authors' carelessness as they magically translocated the study site in a paper by me from Ottawa to Quebec City (page 219).

Also not been changed from the previous edition, is the format of the range maps. While the map of continental USA is professional-looking, many of the borders of Canadian provinces still look as if they were quickly scrawled in with a black marker. More importantly, the content of the Canadian distribution is not always accurate. For example, the map of the Snapping Turtle clearly indicates it is found no farther west than Saskatchewan (which is basically accurate), yet on the same page, the text states it is found as far west as Alberta. The map for the Spotted Turtle omits all of eastern Ontario from the distribution, but includes Quebec, despite the text correctly stating that

the species is no longer known to occur in that province. And the map for the Stinkpot omits all of eastern Ontario. Canadian content is also neglected in the conservation section. Species listed by the IUCN or CITES or the USA's Endangered Species Act are itemized in an extensive table, but those listed by the Canadian Species at Risk Act are overlooked completely.

Despite my complaints, this second edition is an impressive accomplishment. Summarizing so much information is a daunting task and this book provides an amazing gateway into the vast body of scientific literature on North American turtles. Just keep in mind the old adage: don't believe everything you read.

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## The Link: Uncovering Our Earliest Ancestor

By Colin Tudge (with Josh Young). 2009. Little, Brown and Company (a division of Hachette Book Group, Inc.), 3 Centre Plaza, Boston Massachusetts 02108 USA. 272 pages. 28.99 CAN.

Every scientist has a dream of making a big discovery with great impact on his or her field of research. Perhaps no better is this epitomized by a palaeontologist discovering a pristine fossil with possibly grand importance on the evolution of animal life and bearing on our own evolution as human beings. In this book, Colin Tudge describes such a finding in "Ida", a forty-seven million-year-old specimen and the most complete primate fossil ever found. He aims to convey the excitement of this most unusual fossil discovery and describe the importance of the specimen to our understanding of primate evolution. Unearthed by a private fossil collector, the specimen (given the scientific name *Darwinius masillae*) was unveiled to Norwegian palaeontologist Jørn Hurum and later sold under much secrecy to Oslo's Natural History Museum, where it is currently on display.

The book starts off in prose style, as Tudge tells a story of what might have happened as Ida perished long time ago in Eocene times, drowning in a lake with unusually fine conditions for specimen preservation. The site is now known as the Messel Pit, a superb location for fossil hunters just 35 km southeast of Frankfurt, Germany. Once the prosaic tale of Ida is told, the book transforms into a more common form of popular science writing, including detailed descriptions of the specimen itself. However, there is only so much you can tell about a fossil specimen. Tudge expands his book by rather nicely weaving in other aspects of interest, including palaeontology, climate history, the

rise of mammals, primate evolution, and ultimately our own evolution as humans. The result is a rather nice glimpse into how evolutionary science, through the addition of a myriad of small puzzle pieces, aims at an overall understanding of the evolution of life on this planet. However, the book feels repetitive at times, and too much emphasis is spent on how fantastic this particular fossil find is. No doubt Ida is a valuable specimen, but as the book was released immediately following the scientific publication describing the find (Franzen et al. 2009), it is simply too early to tell just how valuable; scientific progress is made only via the continuous critical evaluation of new evidence against old, not through self-proclaimed excellence. Critical readers with a background in science will therefore dislike the salesmanship flavour of the *The Link*. Indeed, Jørn Hurum decided to orchestrate launch of the fossil in a combined scientific and public event. On the other hand, readers with a non-professional interest in science and palaeontology in general may enjoy the book as a fascinating story, especially as it touches upon our own history.

## Literature Cited

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## ENVIRONMENT

**The Algal Bowl: Overfertilization of the World's Freshwaters and Estuaries**

By David W. Schindler and John R. Vallentyne. 2008. The University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1. 334 pages. 34.96 CAD, Paper.

Ever wonder about the origin of all that green slime on your favorite swimming beach? Or why laundry and dish detergents are advertised as phosphate free? If so, let Schindler and Vallentyne guide you through the science and politics of eutrophication.

The authors define eutrophication as "the complex sequence of changes initiated by the enrichment of natural waters with plant nutrients." This is the story of eutrophication by two of the pioneer researchers on the effects of nitrogen and phosphorus enrichment of our freshwaters by human activity. In particular, it was the authors' long-term, whole-lake experiments at the Experimental Lakes Area in northwest Ontario that ushered in ecosystem-based manipulative experimentation, the results of which proved the key role of elevated phosphorus levels in freshwater eutrophication.

Despite the great advances in policy that control point sources of overfertilization, the authors admit that local governments are still largely unaware of the excellent science available on the causes and effects of eutrophication. This book is their attempt to rectify this situation.

It is well recognized that we live on a human-dominated planet. A major way in which we affect global ecosystems is through our impact on the flux of global element cycling. Many of our environmental issues are a function of enhanced nutrient levels in the environment as a result of human activity; carbon in the case of global warming, sulphur with acid precipitation, and phosphorus and nitrogen in the case of eutrophication of our freshwaters and marine estuaries.

None could be more qualified for this task than the two authors. Both have dedicated their lives to understanding the influence of human activity on freshwaters. Their pioneering large-scale manipulation and monitoring of whole lake systems over long periods of time set a new research standard. Deliberately pol-

luting small pristine boreal lakes with phosphorus, nitrogen and carbon in a well-designed experiment provided the definitive evidence for phosphorus overload as the cause of lake eutrophication – and set the stage for significant policy change. The authors' work remains a classic example of the power of manipulative ecosystem-level experimentation.

In an imminently readable style, the authors spell out in 14 chapters the history, science and policy of eutrophication. Preliminary scientific chapters on limnology set the foundation for later discussions of the whole-lake experimental process. In between, the reader is introduced to the role of phosphorus and nitrogen as drivers of eutrophication, followed by a history of the detergent phosphate controversy.

Despite the best scientific efforts, the battle against eutrophication is far from won. Eutrophication has assumed ever more complex forms as freshwater and marine estuaries come under increasing pressure from non-point sources of pollution, climate change, and land use changes around lakes and along coastlines. Furthermore, the problem of eutrophication has moved from freshwater lake systems to the so-called "dead" or anoxic zones of our coastal and estuarine ecosystems. While the science of managing eutrophication is quite well known, applying that knowledge to the actual management of water systems is a complex social and political problem.

The authors are to be commended for distilling years of limnological and eutrophication research into one volume. They have presented the science in a readable manner and have proposed policy and management implications of that research. A glossary and eight pages of colour plates add to the text. We have the science. In one sense, that's easy. Changing our use of water is another issue.

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**Antarctic: First Journey**

By Geoff Carpentier. 2009. Avocet Nature Services, Ajax, Ontario, Canada. [Contact Geoff – Birds [avocet@rogers.com](mailto:avocet@rogers.com) or see [www.avocetnatureservices.com](http://www.avocetnatureservices.com)] 359 pages. 33.50 CAD Paper.

I have known Geoff for more years than I care to remember. He tells some quirky jokes – groaners really – but he is a great birder. He has written, not a guide to wildlife, but a guide to how to go to this marvellous continent. He covers Antarctica, the Falklands, South Georgia, and the sub-Antarctic and Tierra del Fuego. And yes, his humour comes through.

If you plan to go to Antarctica – and you should – you need to read this book first. It details all the of the prerequisites you need to know to turn this from a trip to an adventure. He begins with the items you should consider before you depart. For example he has a packing checklist that is very close to the one I have developed and used successfully myself for many



years. This is followed by the questions you should ask when choosing a cruise and a ship. He points out the difference in experiences you will have between the smaller expedition ships and the huge cruise liners. One additional item that has bothered me recently is the increasing use of the big liners in ice-laden waters. They are not ice-rated ships and I shudder at the thought of evacuating some thousands of people if an accident happened. My friend was on the MV Explorer when it sank with about 150 people and they were lucky to suffer only a harrowing ordeal.

The author not only covers travellers requirements for staying healthy in extreme cold, motion sickness and similar "normal" problems, but the hazards of penguin poop, snow blindness and Zodiac safety. He goes carefully through a comprehensive list of Antarctic [and actually Arctic] phenomena, especially the fascinating science of ice. Carpentier explains the how and the why of expected tourist behaviour in this region.

There is a chapter on the dominant wildlife in the south. While this is well done, it does not have the depth and breadth a full field guide. The author has also provided a guide to all the important areas and islands in the Antarctic and Sub-Antarctic. Many of these have very interesting histories and Carpentier has really done his homework and this provides an enjoyable read. Finally he summarises the region's history. This cannot be detailed [Amundsen gets a quarter of a page], but it will give readers an overview and should stir them to read more.

While I would not categorise this as photo book, there are a lot of good photos. These are not always the usual subjects like wildlife and scenery, but some of the more oddball sights like cryoturbated rock or a page in a historic journal. For those of us who have made the trip it is the photos of fuzzy brown penguins

on Salisbury Plain or the yawning Leopard Seal that will be most endearing.

My one complaint is that the book does not have an index. In a book where there are so many individual items of information that I want to check, this is an annoying omission. There are also some materials that are really basic and I wondered why they were included. Are there really adventure tourists who do not know how to find north or to read latitude and longitude or understand wind chill?

Small informational boxes are scattered throughout the text. These contain essential facts, fun, trivia, anecdotes and notable quotes. There are also some scratchy cartoons and a string of the author's poems. This, along with Carpentier's writing style, makes the book feel how to find north or to read latitude and longitude or understand wind chill? But do not let this overshadow the book's value as a valuable resource. It does really contain all you need and all you should know before you go. I would take a good wildlife guide [such as *A complete guide to Antarctic Wildlife* by H. Shirihi, Princeton University Press] and this book on any trip. This would hold if its your first or n<sup>th</sup> trip. I also think inveterate travellers to anywhere would find many parts of this book useful. Finally a lot of people will find this a fun book to have – so you can confound people with your knowledge of frazil over rime or the non-location of Emerald Isle.

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Reviewer's addenda:

The author, Carpentier, realising an index was a serious omission, has now provided one. To correct your copy you can now download and print an index at [http://www.avocetnatureservices.com/Antarctica\\_First\\_Journey.html](http://www.avocetnatureservices.com/Antarctica_First_Journey.html). The second edition will contain an index.

## Biodiversity and Pest Control

By Li Zhengyue, M. A. Altieri, Zhu Youyong. Beijing Science and Technology Press, 16 Xizhimen South Street, Beijing, China, 100035. 2009. 269 pages, 68.00 CNY.

In agro-ecosystems, either as artificial or semi-artificial ecosystems, their biological diversity directly affects the level of sustainable development of agricultural production. Their relationship with pest control has been a concern of ecologists for a long time. The species diversity in agricultural insect communities is based on the multi-level food chains and food webs linked by nutrition. With the intensification of modern agricultural management, the structure of agricultural landscapes and the biodiversity of agro-ecosystem become simplified, resulting in the failure of natural pest control in many countries or areas. Simple biological diversity of agro-ecosystem caused instability of the relationships among crops, pests and natural enemies, lead to the outbreaks of pests becoming

more and more serious. FAO estimated that grain and cotton production loss 14% and 16% respectively each year due to the damage of pests in the world. China losses billions of dollars annually due to agricultural pests. In the past, simple chemical pesticides were widely used to control pest populations, as do many areas even nowadays. In China, the control of agricultural pests mainly relied on chemical pesticides for many years, consuming large amount of pesticides. According to the statistics, only the active ingredient in the chemicals annually produced is more than 200 000 t in China. Wide application of chemical pesticides inevitably leads to serious environmental problems, such as so called "3R-problem" (resistance, resurgence and residue). In order to manage agricul-

tural pests, in addition to the rational use of chemical pesticides, protection and use of the self-pest-control mechanism in nature is very important, since it is a more effective or natural way to control pests. In agricultural production, more and more people have recognized that by changing the surrounding environment, adjusting the cropping systems, arranging the crop distribution pattern can increase the species number and population size of natural enemies, change the composition of biological communities, improve community diversity and stability, and suppress the number of pests. Although conservation and use of natural enemies in agro-ecosystem is not only beneficial to the ecological pest control, but also helpful to reduce the use of pesticides, improve crop yield and quality, and contribute to the management of agro-ecosystem, however, using natural enemies to control pests in a single-crop-species agro-ecosystem has been challenged practically in the past.

The success of migration and colonization of pests in crops depends on the probability of individual pest finding, feeding and reproducing on host plants, which will be affected by increase of biodiversity in agro-ecosystems. The diversified agro-ecosystem will cause complex visual and olfactory stimulations to pests, and thus disrupt their ability to find host plants. Biological diversity in agro-ecosystems can play the role of shifting the target crops when inter-cropped crops or weeds are similarly suitable for pests, reducing the level of damage of pests to the main crops. This can be applied to a wide area to control pest populations. As opposed to the 1-year-crop habitat, the non-crop habitat types with less disturbance and longer time of vegetation cover have stable heterogeneous environments. Thus they can become suitable sites for the reproduction of parasitic and predatory arthropods due to adequate provision of shelter and/or resources such as prey, pollen and nectar and so on. These natural enemies of crop pests can easily move into the adjacent crop habitats, playing the role of regulation and control of pest populations. Thus, in order to increase the biodiversity of agro-ecosystem and the natural enemies of crop pests, conservation of the biodiversi-

ty of structure of agricultural landscapes and the non-crop habitats are important.

In China, the ecological management of agricultural pests is just beginning, and consequently urgently needs a comprehensive book to introduce the theories and practices in this field. The book *Biodiversity and Pest Control* theoretically elucidates the relationships between biological diversity and control of plant pests, and gave abundant examples of practices. This book focussed on the ways of using biological diversity to maintain the stability of pest population in agro-ecosystems, discussed inter-cropping, tillage layer coverage, weed management, techniques of crop-surrounding plant control and so on. The main contents are: Chapter 1, ecological functions of biodiversity and its relationship with agricultural production; Chapter 2, relationships between plant diversity and stability of insect community in agro-ecosystems; Chapter 3, the survey and sampling method of insect diversity; Chapter 4, insect management in complex cropping agro-ecosystems; Chapter 5, biodiversity and sustainable control of insect pests in rice field; Chapter 6, cultivation of ground cover plant and pest management in orchard; Chapter 7, impacts of surrounding environment of farmland on the insect populations; Chapter 8, weed control and pest population control; Chapter 9, pests dynamics in agroforestry ecosystems; Chapter 10, vegetation diversity and pest population control in agro-ecosystems; Chapter 11, agricultural biological diversity and invasion of alien insects.

The book is well written with few errors and strong readability. It may be used as a good reference for entomologist or ecologists or persons who engage in agricultural or biological research, education, production and management, or other persons who are interested in these fields.

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## Comprehensive Research on Ecosystems of China

By Sun Honglie. 2009. Beijing Science and Technology Press, 16 Xizhimen South Street, Beijing, China, 100035. 388 pages, 89.00 CNY.

The territory of China spans a vast area, extending from tropical to cold regions from south to north, and from humid or rainy to arid or semi-arid regions from east to west, covering diversified types of ecosystems. Obviously, clear understanding the structures, functions and dynamics of these complex ecosystems need integrative and long-term investigations. In-depth and systematic research on these ecosystems can provide essential information for the scientific assessment

of their health status and successional trends, which can also reflect the changes of the local environmental conditions.

Ecosystem research in China was rather late compared with other developed countries, and 20 years ago, such research was also rather scattered and isolated without common objectives and unified scientific methods of observation and measurement. This made it hard to make scientific and systematic comparisons



and analysis of the data accumulated by research stations at the country-scale. Having recognized such an embarrassment, in 1988, China Ecosystem Research Network (CERN) was established by the Chinese Academy of Sciences. This included most representative ecological research stations over China. These are located in the typical ecological regions and belong to the typical ecosystem types. The CERN was set up with the aim of formulating common items of scientific research, observation, and measurement at different locations in order to integrate the works of individual ecological research stations at a common scientific basis. So far, 20 years has passed since the establishment of CERN, and great changes could have happened in these ecosystems, thus, to sum up the trends of changes in these based on the data accumulated over time, seemed to be very necessary.

The book *Comprehensive Research on Ecosystems of China* systematically sums up the main progresses and results of the long-term ecological observations, researches and experiments in the ecological stations of CERN, for the 20 years since its establishment, covering the typical ecosystems in typical ecological regions, such as farmlands, forests, grasslands, deserts, water bodies and so on, and concerned with the water cycling, carbon cycling, nutrient cycling, biodiversity of the terrestrial ecosystems, the ecological functions of water body ecosystems, as well as the atmospheric environment. In addition, the book also summarized the processes of development of CERN since its establishment, and the ideas and layouts for future development.

The main contents of the book are as follows, Chapter I The history of design and construction of China Ecosystem Research Network. Chapter II Agricultural ecosystems of China, including (1) evolution of soil quality, productivity and environmental effects of intensive agro-ecosystems, (2) nutrient cycling of intensive agro-ecosystems, (3) water cycling of intensive agro-ecosystems, (4) structure, function and productivity of agro-ecosystems, (5) construction of the core zone of national food production, (6) construction of the circular agriculture and its environment. Chapter III Forest ecosystems of China, including (1) structure and biodiversity of forest ecosystems, (2) functions of forest ecosystems and their responses to global changes, (3) restoration of degraded forest ecosystems and the techniques of optimized management. Chapter IV Grassland ecosystems of China, including (1) productivity and stability of grassland ecosystems, (2) relationship between biological diversity and productivity of grassland ecosystems, (3) nutrient cycling of grassland ecosystems, (4) responses and adaptations of grassland ecosystems to global changes, (5) grazing ecology and rational utilization of grassland ecosystems, (6) pests and rodents of grassland ecosystems and their control, (7) prospects for future research in grassland ecosystems. Chapter V Desert ecosystems of China, including (1) adaptability of desert plants in

desert ecosystems, (2) desertification and its control in China, (3) some techniques and examples of ecological restoration and reconstruction in desertified grasslands, (4) construction and management of desert oasis, (5) sand damages to the major engineering projects and the control techniques and application examples. Chapter VI Wetland ecosystems of China, including (1) hydrological processes and ecological effects of wetlands, (2) carbon and nitrogen biogeochemical cyclings, and the driving mechanism in wetland ecosystems, (3) characterization of the degraded wetland ecosystems and the evaluation indexes. Chapter VII Fresh water lake ecosystems of China, including (1) interaction between the main biogenic elements and primary producers in fresh water lake ecosystems, (2) relationship between N/P and algal blooms occurrence, (3) top-down effects of predator on primary producers, (4) impacts of external environmental conditions on lake ecosystems. Chapter VIII Gulf ecosystems of China, including (1) mariculture ecology, (2) structures and functions of gulf ecosystems, (3) long-term changes and succession of gulf ecosystems. Chapter IX Water cycling in terrestrial ecosystems of China, including (1) overview of the study of water cycling in terrestrial ecosystems within the network of CERN, (2) characteristics of water consumption by crops in northern agro-ecosystems and regional differences, (3) hydrological processes of different types of forest vegetation and their differences, (4) relationships between vegetation and water in northern desertified areas and spatial divergence distribution, (5) characteristics of stable isotope in precipitation of China and discrimination of source of water vapour, (6) comparisons of water qualities among terrestrial ecosystems of different regions. Chapter X Carbon cycling in terrestrial ecosystems of China, including (1) overview of the study of carbon cycling in terrestrial ecosystems of China, (2) carbon storages, spatial patterns and environmental control factors of terrestrial ecosystems, (3) spatial and temporal changes and control mechanisms of carbon sink-source functions in terrestrial ecosystems, (4) impacts of ecosystem management on carbon cycling and effects of carbon sink. Chapter XI Nutrient cycling in terrestrial ecosystems of China, including (1) progresses of the study of nutrient cycling in terrestrial ecosystems within the network of CERN, (2) nutrient cycling and productivity of terrestrial ecosystems, (3) nutrient cycling of terrestrial ecosystems and evolution of soil quality, (4) nutrient cycling of terrestrial ecosystems and effects of environment, (5) driving mechanisms of nutrient cycling and balance of terrestrial ecosystems. Chapter XII Biological diversity of terrestrial ecosystems of China, including (1) biological monitoring of terrestrial ecosystems within CERN, (2) progresses of biodiversity study of terrestrial ecosystems. Chapter XIII Ecological functions of terrestrial water body ecosystems of China, including (1) environmental quality of water bodies,

(2) service values of water body ecosystems, (3) health assessment of water body ecosystems. Chapter XIV Atmospheric environment of terrestrial ecosystems of China, including (1) overview of the study on the changes of atmospheric environment within the network of CERN, (2) changes in radiation environment of terrestrial ecosystems, (3) changes in aerosol optical thickness of terrestrial ecosystems, (4) changes in atmospheric ozone concentration of terrestrial area. Chapter XV Some thoughts on strategic layout and development of CERN.

Compared with the book *Chinese Ecosystems*, written by Sun Honglie and published by Science Press, Beijing, in 2005, which generally summed up some typical ecosystems of China, the book *Comprehensive Research on Ecosystems in China* is deeper and

more detailed, and could be regarded as a sister book or a companion volume of the former. Hopefully this book would contribute to the deeper understanding of the various aspects of different Ecosystems of China. The book is suitable for the professionals who engage in ecology, biology, agriculture, forestry, water sciences or environmental sciences, or other persons who are interested in these fields.

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<sup>2</sup>Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd. Songjiang, Shanghai, China. 201600)

## Theoretical Basis and Practical Modes of Returning Farmland to Forest or Grassland

By Li Xianwei, Zhang Jian, Hu Tingxing, Luo Chengde. 2009. Beijing Science and Technology Press, 16 Xizhimen South Street, Beijing, China, 100035. 450 pages. 75.00 CNY.

For thousands of years, most of Chinese farmers have been bound to the land. They reclaim the lands around their living areas for crop cultivation, regardless of whether these lands are ecologically suitable for grain production or not, leading to serious environmental problems in some areas. The Chinese government made a strategic policy a few years ago to return some infertile and unsuitable farmland to forest or grassland to protect the environment of these areas.

In China, returning farmland to forest or grassland, or in other terms, the grain for green project, refers to ecological engineering to convert the present farmland located in unstable slope land, or desertified arable land, or ecologically important but fragile land, or the land with frequent or serious soil erosion, or lower grain production etc, to forest or grassland, so as to improve and protect the environment. Actually, such policy and practice has a long history in China. However, for a long time, such practices were only conducted in sporadic areas. In the world, at least as early as the 20<sup>th</sup> century, in the United States there was a precedent of successful practice of returning farmland to forests, especially in the state of New York. In China, the project is mainly implemented in about 20 provinces, cities and regions in north, west and central China. The natural environments and social conditions of these areas are mostly quite harsh and poverty stricken. These include places such as the inaccessible mountainous or semi-mountainous areas with little valley or plains, arid or semi-arid areas, both sides of the sources of rivers, areas around the lakes and reservoirs, etc.

Returning some farmland to forest or grassland is an urgent need in some areas with fragile and degraded environment, and of importance for restoration, protection and construction of the environment in these

areas, and long-term survival of millions of local people and development of the local economy. At present, in China, about 37.5% and 18.2% of land areas suffer from soil erosion and desertification, respectively, which mainly resulted from blindly practising long-term deforestation and reclamation. According to a national survey of land resources, the slope farmland with above 25 degrees makes up 6.06 million km<sup>2</sup>. The deforestation and reclamation increase the arable land area and subsequent grain production came with high environmental costs. The middle and upper reaches of the Yangtze and Yellow River have become one of the most serious soil-eroded areas in the world, due to the deforestation and reclamation on steep slopes of the river banks. Two-thirds of more than 2 billion tons of sediment flowing into the Yangtze and Yellow River each year come from the slope farmland, which further lead to the siltation of rivers and lakes, and increase the flooding or water shortage in lower reaches.

In China, the implementation of the project of returning farmland to forest or grassland, not only can fundamentally solve the problem of soil erosion, effectively enhance the capacity of water conservation, improve the environmental quality, increase the capacity of water logging-prevention and drought-resistance, increase the productivity of existing farmland, change the traditional farming habits, adjust and optimize the industrial structure in rural areas, promote the local economic development, help people to eliminate poverty, promote the development of the industry and agriculture in these areas, but also can provide ecological protection for the middle and lower reach areas, as well as the healthy and sustainable development of the environment, society and economy of the whole country. The project of returning farmland to forest or grassland is one part of the national strategy of sustainable



development taking into account the ecological, economic and social effects. As a win-win deal, it will make barren hills green while bringing benefits to farmers. With ample supplies of grain and other agricultural products, China is currently in a good position to accelerate the project, and the rural households, subsidized with free grain, seeds and seedlings as well as cash for living expenses, were enthusiastic to participate in the project.

Practices in recent years have proved that the project of returning farmland to forest or grassland has played active roles in ecological, economic and social aspects both locally and national wide. Therefore, to summarize the theoretical basis and practical modes of returning farmland to forest or grassland in time seems to be very necessary. The publication of the book *Theoretical basis and practical modes of returning farmland to forest or grassland* exactly meets such demands.

The book started from the systematically elucidation of the history of returning farmland to forest or grassland, then discussed the concept, theoretical basis and technical modes of such ecological engineering in detail. The main contents are as follows: Chapter 1, review on the history of returning farmland to forest; Chapter 2, degraded ecosystems of steep slope farmland; Chapter 3, theoretical basis for returning farmland to forest; Chapter 4, industrial modes and techno-

logical modes for returning farmland to forest; Chapter 5, the vegetation structure and yield characteristics of the forest-grass complex modes; Chapter 6, fine root characteristics of the forest-grass complex modes; Chapter 7, species diversity of the forest-grass complex ecosystem; Chapter 8, soil amelioration and nutrient management of the forest-grass complex modes; Chapter 9, soil and water ecology and conservation in the forest-grass complex modes; Chapter 10, economic effects of the forest-grass complex modes; Chapter 11, theoretical basis and methods for sustainable development of the forest system returned from farmland; Chapter 12, sustainable management strategies of the forest system returned from farmland.

This book would become a good reference for the persons who are engaged in restoration ecology or ecological engineering, forestry, agriculture and environmental science, etc, as well as teachers and students who major in the relevant fields, or any other persons who are interested in this field.

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## NEW TITLES

Prepared by Roy John

† Available for review \* Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

## ZOOLOGY

\* **Amphibian Biology – Volume 8, Amphibian Decline.** Edited by Harold Heatwole and John W. Wilkinson. 2009. Surrey Beatty & Sons, 43 Rickard Road, Chipping Norton 2170, NSW, Australia. 330 pages. 157 USD Cloth.

\* **Amphibian Ecology and Conservation: a Handbook of Techniques (Techniques in Ecology & Conservation).** Edited by C. Kenneth Dodd Jr. 2009. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario M3C 1J9. 584 pages. 32 GBP, Paper.

**Bats of Britain, Europe and Northwest Africa.** By Christian Dietz, Otto von Helversen, and Dietmar Nill. 2009. Christopher Helm, A&C Black, 37 Soho Square, London W1D 3QZ United Kingdom. 56 USD Cloth.

\* **The Birds of Barbados.** By P. A. Buckley, E. B. Massiah, M. B. Hutt, F. G. Buckley, and H. F. Hutt. 2009. British Ornithologists' Union, P.O. Box 417, Peterborough PE7 3FX United Kingdom. 295 pages. 40 GBP, Cloth.

**Collins Bird Guide: The Most Complete Guide to the Birds of Britain and Europe.** By Lars Svensson, Killian Mullarney, Dan Zetterstrom and Peter J. Grant. Edition 2 March 2010. Harper Collins Publishers Ltd. 1995 Markham Road, Scarborough, Ontario M1B 5M8. 30 USD Paper.

\* **A Photographic Guide to the Birds of Jamaica.** By Ann Haynes-Sutton, Audrey Downer, Robert Sutton, and Yves-Jacques Rey-Millet. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey 08540. 304 pages. 29.95 USD, Paper.

\* **Birds of Eastern North America and Birds of Western North America.** By Paul Sterry and Brian E. Small. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey 08540. 335 and 416 pages. 18.95 USD. Paper.

\* **Corvus – A Life With Birds.** By E. Woolfson. 2009. House of Anasi Press Inc., 110 Spadina Avenue, Suite 801, Toronto, Ontario M5K 2K4. 337 pages, 17.95 CAD, Paper.

\* **Frogs: Inside Their Remarkable World.** By Ellin Beltz. Firefly Books Ltd., 2005, USD 26.06 (Hardcover).

**Grouse.** By Adam Watson and Robert Moss. 2008. Harper Collins Publishers Ltd. 1995 Markham Road, Scarborough, Ontario M1B 5M8. 50 USD Paper.

**Mammals of Europe, North Africa and the Middle East.** By S Aulagnier, P Haffner, AJ Mitchell-Jones, F Moutou and J Zima 2009. Christopher Helm, A&C Black, 37 Soho Square, London W1D 3QZ, United Kingdom. 35 USD Cloth.

**Britain's Reptiles and Amphibians: A Guide to the Reptiles and Amphibians of Great Britain, Ireland and the Channel Islands.** By Howard Inns. 2009. WildGuides Ltd., PO Box 680, Maidenhead, Berkshire, SL6 9ST. United Kingdom. 30 USD Paper.

**New Holland European Reptile and Amphibian Guide.** By Axel Kwet. 2009. New Holland Publishers, Garfield House, 86-88 Edgware Road, London W2 2EA. United Kingdom. 252 pages. 15 GBP, Cloth.

\* **Natural History of West Indian Reptiles and Amphibians.** By Robert W. Henderson and Robert Powell. 2009. University Press of Florida, 15 NW 15th Street, Gainesville, Florida 32611. 576 pages. 85.00 USD Cloth.

**Turtles: the Animal Answer Guide.** By Whit Gibbons and Judy Greene. John Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363. 184 pages. 45.00 USD, Cloth.

**An Atlas of Wader Populations in Africa and Western Eurasia.** By Simon Delany, Tim Dodman, David Stroud and Derek Scott. 2009. Wetlands International, PO Box 471, 6700 AL Wageningen, The Netherlands, 81 USD Paper.

**Wildfowl.** By David Cabot, 2009. Harper Collins Publishers Ltd. 1995 Markham Road, Scarborough Ontario M1B 5M8. 83 USD, Cloth.

#### BOTANY

**The Vegetative Key to the British Flora: A New Approach to Plant Identification.** By John Poland and Eric Clement. 2009. Published by John Poland, Distributed by NHBS Environment Bookstore, 2-3 Wills Road, Totnes, Devon TQ9 5XN, United Kingdom. 41 USD Paper.

**Grasses of the British Isles.** By Tom Cope and Alan Gray. 2009. Botanical Society of the British Isles, Botany Department, The Natural History Museum, Cromwell Road, London, SW7 5BD United Kingdom. 33 USD Paper.

\* **Metamorphosis of Plants.** By Johann Wolfgang von Goethe. Photographs and Introduction by Gordon L. Miller. 2009 [First published in 1790]. The MIT Press, 55 Hayward Street, Cambridge, Massachusetts 02142-1493. 155 pages. 21.95 USD, Cloth.

\* **Sedges, of Indiana and the Adjacent States: the Non-Carex Species.** By Paul E. Rothrock. 2009. Indiana Academy of Science, Indianapolis, Indiana 46204. 271 pages. 45.00 USD. Cloth.

#### ENVIRONMENT

\* **Antarctica – First Journey. The Traveller's Resource Guide.** By Geoffrey Carpentier. 2009. Avocet Nature Services. 359 pages. 33.50 CAD Paper.

**The Meteorites of Alberta.** By A. Whyte. 2009. University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1. 316 pages. 34.95 CAD, Paper.

**Environment, Biodiversity and Conservation in the Middle East – Proceedings of the First Middle Eastern Biodiversity Congress, Aqaba, Jordan.** Edited by F. Krupp, L. Musselman, M. Kotb, and I. Weidig. 2009. Pensoft Publishers, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 220 pages. EUR 44.00.

**Animal Biodiversity in the Middle East – Proceedings of the, First Middle Eastern Biodiversity Congress, Aqaba, Jordan.** Edited by E. Neubert, Z. Amr, S. Taiti and B. Gumus. 2009. Pensoft Publishers, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 252 pages. EUR 50.00.

**Theoretical Basis and Practical Modes of Returning Farmland to Forest or Grassland.** By Li Xianwei, Zhang Jian, Hu Tingxing, Luo Chengde, Science Press, 2009. 450 pages. 75.00 RMB.

**Wildlife in a Changing World – An Analysis of the 2008 IUCN Red List of Threatened Species.** Edited by J.-C. Vié, C. Hilton-Taylor, S.N. and Stuart. 2009. Rue Mauverney 28, Gland, 1196, Switzerland. 2009. 180 pages. 36.00 USD Paperback.

#### MISCELLANEOUS

**Sexy Orchids Make Lousy Lovers.** By Marty Crump. 2009. The University of Chicago Press, 1427 East 60th Street Chicago, Illinois 60637 USA. 232 pages, 25 USD, Cloth.



# News and Comment

## *Marine Turtle Newsletter*, Number 124, April 2009

EDITORIALS: The Continuing shame of Orissa — *Eric Hawk*; A Little Learning... The Price of Ignoring Politics and History — *Kartik Shanker, BC Choudhury, Ashish Fernandes, Sanjiv Gopal, Areeba Hamid, Chandrasekhar Kar, Suresh Kumar, Janaki Lenin, Biswajit Mohanty, Bivash Pandav, Sudarshan Rodriguez, Aarthi Sridhar, Wesley Sunderraj, Basudev Tripathy, Romulus Whitaker, Sejal Worah and Belinda Wright*. ARTICLES: The Marine Turtle Product Trade in Viet Nam — *Daniel Stiles*; Sea Turtles on Clipperton Island (Eastern Tropical Pacific) — *Olivier Lorvelec, Michel Pascal and Jacques Fretey*; Unexpected Visitors to the Eastern Caribbean: Loggerheads Nest at Buck Island Reef National Monument — *Clayton Pollock, Ian Lundgren, Lindsay Albright, Amber Avestruz, Julia Polan and Zandy Hillis-Starr*; Eight Nests Recorded for a Loggerhead Turtle within One Season — *Anton D. Tucker*.

MEETING REPORTS – BOOK REVIEWS – ANNOUNCEMENTS – NEWS & LEGAL BRIEFS – RECENT PUBLICATIONS.

*The Marine Turtle Newsletter* is edited by Lisa M. Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA; and Matthew H. Godfrey, NC Sea Turtle Project, North Carolina Wildlife Resources Commission, 1507 Ann Street, Beaufort, North Carolina 28516 USA. Subscriptions and donations to the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael S. Coyne (Managing Editor), Marine Turtle Newsletter, A321 LSRC, Box 90328, Nicholas School of Environment and Earth Sciences, Duke University, Durham, North Carolina 27708-0328 USA; e-mail: [mcoyne@seaturtle.org](mailto:mcoyne@seaturtle.org).

## Editor's Report for Volume 122 (2008)

Mailing dates for issues in volume 122: (1) 15 October 2008; (2) 19 November 2008; (3) 19 January 2009; (4) 15 April 2009.

A summary of membership and subscriber distribution totals for 2008 is given in Table 1. The number of articles and notes in volume 122 is summarized in Table 2 by topic; totals for Book Reviews and New Titles are given in Table 3, and the distribution of content by page totals per issue in Table 4.

The journal was printed at Gilmore Printers, Ottawa, and thanks are due business representative Tom Smith and customer representative Chuck Graham for overseeing production. Wendy Cotie prepared galleys and page proofs. Elizabeth Morton edited and proofed the galleys. Sandra Garland, the webmaster for the Ottawa Field-Naturalists' Club, posted tables of contents on the OFNC website. Leslie Cody prepared the Index for volume 122. Duties of the Business Manager were assumed by Treasurer Frank Pope, assisted by Assistant Treasurer Jim Ward. Roy John requested books for review and selected reviewers, edited submitted reviews, and prepared the new titles listings.

Manuscripts (excluding book reviews, notices, and reports) submitted to *The Canadian Field-Naturalist* totalled 48 in 2008. The following reviewed papers submitted in 2008 (with number of manuscripts reviewed in parentheses if more than one):

*Associate Editors:* R. Anderson, Canadian Museum of Nature, Ottawa, Ontario (2); W. B. Ballard, Texas Tech University, Lubbock, Texas (13); C. D. Bird, Erskine, Alberta (3); R. R. Campbell, St. Albert, Ontario (2); P. M. Catling, Agriculture and Agri-Food Canada, Ottawa, Ontario (4); B. W. Coad, Canadian Museum of Nature, Ottawa, Ontario (3); A. J. Erskine, Sackville, New Brunswick (6); D. F. McAlpine, New Brunswick Museum, Saint John, New Brunswick (3); D. W. Nagorsen, Mammalia Biological Consulting, Victoria, British Columbia (6); W. O. Pruitt, Jr., University of Manitoba, Winnipeg, Manitoba (12);

TABLE 2. Number of articles and notes published in *The Canadian Field-Naturalist*, Volume 122 (2008), by major field of study.

Subject	Articles	Notes	Total
Mammals	15	16	31
Birds	6	4	10
Amphibians and reptiles	4	0	4
Fish	6	0	6
Plants	4	2	6
Other	1	0	1
Total	36	22	58

TABLE 3. Number of reviews and new titles published in the Book Review section of *The Canadian Field-Naturalist*, Volume 122, by topic.

	Reviews	New Titles
Zoology	18	55
Botany	7	6
Environment	10	21
Miscellaneous	7	7
Total	42	89

*Others:* M. F. Docker, University of Manitoba, Winnipeg, Manitoba; L. Carbyn, Canadian Wildlife Service, Edmonton (2); D. Cluff, Environment and Natural Resources of the Northwest Territories, Yellowknife, Northwest Territories; S. Cooke, Carleton University, Ottawa, Ontario; G. Fitzgerald, Université de Montréal, Saint-Hyacinthe, Quebec; B. Freedman, Dalhousie University, Halifax, Nova Scotia; F. H. Harrington, Mount Saint Vincent University, Halifax, Nova Scotia; S. J. Hecnar, Lakehead University, Thunder Bay, Ontario (2); C. S. Houston, Saskatoon, Saskatchewan; R. James, Sunderland, Ontario (2); G. W. Kuzyk, British Columbia Ministry of the Environ-

TABLE 1. The 2008 circulation of *The Canadian Field-Naturalist* (2007 in parenthesis). Compiled by Frank Pope from the mailing list for 122(4). Forty percent of membership dues and 100% of subscriptions go to publication of *The Canadian Field-Naturalist*. Members vote on Club affairs; subscribers and institutions do not.

	Canada	USA	Other	Total
Memberships				
Family & individual	552 (544)	24 (25)	2 (5)	578 (574)
Subscriptions				
Individual	101 (115)	37 (44)	3 (3)	141 (162)
Institutional	129 (197)	185 (224)	30 (33)	344 (454)
Total	782 (856)	246 (293)	35 (41)	1063 (1190)

Note: 22 countries are included under "Other" (outside Canada and United States).



ment, Victoria, British Columbia; V. Lesage, Fisheries and Oceans Canada, Maurice Lamontagne Institute, Mont-Joli, Quebec; J. McRoberts, Texas Tech University, Lubbock, Texas; D. Mech, U.S. Geological Survey, and The Raptor Center, University of Minnesota, St. Paul, Minnesota (2); T. Meier, Denali National Park, Alaska; R. I. G. Morrison, Environment Canada, Ottawa, Ontario; D. Naughton, Canadian Museum of Nature, Ottawa, Ontario; R. W. Nero, Winnipeg, Manitoba; T. J. Nolen, Ryan Veterinary Hospital, Philadelphia, Pennsylvania; M. J. Oldham, Ontario Ministry of Natural Resources, Peterborough, Ontario; G. Proulx, Alpha Research & Management Ltd., Sherwood Park, Alberta (2); R. Reeves, Okapi Wildlife Associates, Hudson, Quebec; C. Renaud, Canadian Museum of Nature, Ottawa, Ontario; F. W. Schueler, Bishops Mills Natural History Center, Bishops Mills, Ontario (2); F. Scott, Acadia University, Wolfville, Nova Scotia; D. Seburn, Ottawa, Ontario;

C. N. Somers, University of Regina, Saskatchewan; I. Stirling, Canadian Wildlife Service, Edmonton, Alberta; M. Weinrich, Whale Center of New England, Gloucester, Massachusetts.

I am also indebted once again to the President and Council of The Ottawa Field-Naturalists' Club and to Chairman Ron Bedford and the Publications Committee of the OFNC for continuing support, to the

TABLE 4. Number of pages per section published in *The Canadian Field-Naturalist*, Volume 122 (2008), by issue.

	Issue				Total
	1	2	3	4	
Articles	64	67	63	58	252
Notes	18	16	15	0	49
Book Reviews*	8	12	13	19	52
Tributes	4	0	0	0	4
CFN/OFNC Reports **	0	2	8	4	14
News and Comment	4	2	1	3	10
Index	0	0	0	19	19
Advice to Contributors	0	1	0	1	2
Total	98	100	100	104	402

\* Total pages for book review section include both reviews and new titles listings.

\*\* Includes CFN Editor's report in number 2, Minutes of the OFNC Annual Business Meeting in number 3, and OFNC Awards in number 4.

Canadian Museum of Nature for access to its library and the facilities at the Natural Heritage Building, 1740 Pink Road, Gatineau (Aylmer), Quebec, and to Joyce for continuing support.

FRANCIS R. COOK  
*Editor*

## Advice for Contributors to *The Canadian Field-Naturalist*

### Content

*The Canadian Field-Naturalist* is a medium for the publication of scientific papers by amateur and professional naturalists or field biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

### Manuscripts

Submit by e-mail or post **to the Editor**, in either English or French, one complete manuscript **written in the journal style**. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Manuscripts should be formatted for standard-size paper, **doublespaced throughout**, generous margins to allow for copy marking, and **each page numbered**. For Articles and Notes provide a citation strip, an abstract, and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Be certain to check that all text citations are included either in the *Documents Cited* (for unpublished reports, manuscripts and web pages) indicated in text with an \* after date or *Literature Cited* for published/printed and widely circulated books and papers.)

Check recent issues (particularly Literature Cited) for journal format. Either "Canadian" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and **le Grand Larousse Encyclopédique** are the authorities for spelling.

### Illustrations

Electronic versions of photographs should be high resolution. Photographic reproduction of line drawings should be **no larger than a standard page**.

### Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the journal.

### Special Charges — Please take note

Authors **must share in the cost of publication** by paying \$90 for each page, plus \$30 for each illustration (any size up to a full page), and up to \$90 per page for tables (depending on size). Authors may also be charged for their changes in proofs. Reproduction of color photos is extremely expensive; price quotations may be obtained from the Editor.

Limited journal funds are available to help offset publication charges to authors without grants or institutional support. Requests for financial assistance should be made to the Editor when the manuscript is submitted and noted when the galley is returned.

### Reprints

An order form for the purchase of reprints or pdf will accompany the galley proofs sent to the authors. Invoices for publication costs will be sent when the submission is published.

FRANCIS R. COOK, Editor  
RR 3 North Augusta, Ontario K0G 1R0 Canada



Book Reviews

ZOOLOGY: Birds of Borneo, Brunei, Sabah, Sarawak, and Kalimantan — Resource Insects of China — Mammals of India — The Migration of Birds: Seasons on the Wing — A Photographic Guide to Seashore Life in the North Atlantic: Canada to Cape Cod — Turtles of the United States and Canada — The Link: Uncovering Our Earliest Ancestor	182
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# The CANADIAN FIELD-NATURALIST

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COVER: "Standing-over in captive Coywolves, *Canis latrans* × *lycaon*." See note by Johnathan G. Way, pages 262-264.



# The Canadian Field-Naturalist

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## Coywolf, *Canis latrans* × *lycaon*, Pack Density Doubles Following the Death of a Resident Territorial Male

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Way, Jonathan G., Brad C. Timm, and Eric G. Strauss. 2009. Coywolf, *Canis latrans* × *lycaon*, pack density doubles following the death of a resident territorial male. *Canadian Field-Naturalist* 123(3): 199–205.

We studied a subset of four radio-collared individuals that were a part of a larger study documenting Coywolf (*Canis latrans* × *lycaon*; Eastern Coyote) ecology in an urbanized landscape (Cape Cod, Massachusetts), and report on the territory of a typical sized pack that was subdivided roughly in half following the death of the breeding male from the original (“Centerville”) pack. The original residents lived in a winter pack size (i.e., after pup/juvenile dispersal) of three or four individuals in a 19.66 km<sup>2</sup> territory and a density of 0.15–0.20 individuals/km<sup>2</sup>, as determined by radio-tracking and direct observations, with their territory bordering that of other monitored packs. Following the death of the breeding male, two other radio-collared Coywolves (a young male from the original Centerville pack and a young female from a bordering pack) shifted their respective territories to overlap the majority of the original Centerville pack’s territory. These two groups were the same size as the original pack (three or four individuals each) but occupied smaller territories (5.28 km<sup>2</sup> and 12.70 km<sup>2</sup>) within the previous pack’s territory. The combined density for the two new packs was estimated at 0.33–0.45 individuals/km<sup>2</sup> or 2.2 times greater than the former pack’s density and was 2.5 times (0.38–0.50 individuals/km<sup>2</sup>) greater when accounting for the slight (12%) overlap between the territories of the two new packs. Our results suggest that local Coyote/Coywolf density (i.e., at the pack level) may increase following the death of the breeding male of a given pack, probably because of the reduced (or lack of) protection of territorial boundaries. This finding has particular relevance to Coyote/Coywolf management programs aimed at reducing local densities via removal of individuals from these populations. Further implications exist for enriching our understanding of the trophic dynamics of urbanized habitats.

**Key Words:** Coywolf, Eastern Coyote, *Canis latrans* × *lycaon*, density, management, pack, population increase, territoriality.

Home range, or the area that an animal uses, is one of the most basic and critical life-history traits of wildlife species that we must understand in order to devise and implement effective conservation and/or management strategies (Powell 2000). As noted by Powell (2000: 74), “knowing animals’ home ranges provides significant insights into mating patterns and reproduction, social organization and interactions, foraging and food choices, limiting resources, important components of habitat, and more” for those animals. Similarly, the territory is the portion of an animal’s home range that is guarded by a group/individual and is a term often associated with carnivores (Clark et al. 1999; Mech and Boitani 2003a: 19–20). Depending on the species, a territory may be the animal’s entire home range or it may be only part of it (Powell 2000).

A consistent theme of canid biology is that the majority of a wild dog’s home range is guarded as its ter-

ritory (MacDonald and Sillero-Zubiri 2004: 6). Coywolves (*Canis latrans* × *lycaon*; also called Eastern Coyote; Way et al. 2010) are similar to Coyotes (*C. latrans*) and Wolves (*C. lupus*) in that they live in territorial social groups (i.e., packs) consisting of a breeding pair, some of their full-grown offspring (termed beta- or pack-associates; usually one- or two-year-old individuals), and pups of the year (Gese et al. 1996b; Mech et al. 1998; Mech and Boitani 2003b; Patterson and Messier 2001; Way et al. 2002a; Way 2003). In our study area, previous research has documented that Coywolves live in territorial packs (i.e., most of their home range is guarded as a territory) typically consisting of three or four adult individuals (Way et al. 2002a), although larger packs of five or six individuals have been observed (Way 2003, 2007a). Because of these previous findings, we will hereafter refer to our findings as Coywolf territories and packs. In addition

to territorial packs, lone individuals (termed nomads or transients) travel among resident packs and typically have much larger home ranges (see Parker 1995; Mech and Boitani 2003b; Way 2007b). Knowledge of a canid's territory and pack size (along with the number of transients in a population) can aid wildlife managers in more accurately estimating the size and density of local populations (Mech and Tracy 2004).

As top-order predators in many areas, Coyotes and Coywolves may have increased impacts on the trophic dynamics of urban habitats (Faeth et al. 2005). As such, it is critical that managers be able to make accurate estimations of their populations. In this paper we report on the territory of a normal-sized Coywolf pack (the Centerville pack) being used and partitioned between two packs following the death of two of the original pack's resident adults.

## Methods

Fieldwork was conducted from 1998 to 2008 in the urbanized town of Barnstable (155 km<sup>2</sup>), Cape Cod, Massachusetts, where human population density is 308 people/km<sup>2</sup> and housing density is 161/km<sup>2</sup> (Figure 1). Cape Cod (1024 km<sup>2</sup>) is a residential area interspersed with numerous small (5–10 ha) and several large (100–500 ha) conservation areas. Areas of Cape Cod are rapidly urbanizing. Available habitat is fragmented, but it is connected via corridors such as powerlines, golf courses, railroad tracks, and even secondary roads. Most of the neighborhoods are not fenced, and Coywolves are readily able to travel through these areas to gain access to various portions of their territories (Way et al. 2004).

Coywolves were captured in box traps baited with supermarket meat scraps and road-killed Eastern Grey Squirrels (*Sciurus carolinensis*) (Way et al. 2002b). Following capture, Coywolves were fitted with a radio-collar (MOD 335 and MOD 400 collars; Telonics Inc., Mesa, Arizona, USA) for monitoring purposes. Radio-telemetry protocols are fully described by Way et al. (2002a) and Way et al. (2004). Portable receivers (Custom Electronics, Urbana, Illinois, USA) and hand-held 3-element Yagi antennas were used to radio-track both on foot and from a vehicle. Due to the abundance of roads present in the landscape we were working in, we mostly restricted our activities to cars, as Coywolves did not react to them as much as they did to people (e.g., by running away; J. Way, unpublished data). Occasionally we approached animals as close as possible on foot without disturbing them. Using a vehicle, we homed in on each individual's signal until its location had been pinpointed using the loudest-signal method (see Way et al. 2004). We used binoculars, spotting scopes, and video-cameras during daytime observations, and city street lights, night vision scopes, binoculars, and occasionally headlights during nighttime observations (Way et al. 2002a, 2004). It is important to stress that we had minimal influence on

Coywolf behavior despite obtaining highly accurate radio-locations. The majority of our sightings occurred with our car engine off, and observations (e.g., a Coywolf crossing a street near our research vehicle) indicated that we rarely altered a given individual's behavior (Way et al. 2002a). Radio-collared Coywolves were tracked throughout a 24-hour time period to ensure accurate representation of activity and movements, although 33% of radio-locations were collected during crepuscular hours, when Coywolves were most visible.

Radio-collared Coywolves were often seen with untagged companion(s), especially when at rendezvous sites (Way 2003, 2007a). A detailed description (e.g., size, coloration, distinguishing markings, and behavior) of the animals without radio-collars was made during every direct observation. In this manner, the unmarked individuals were identified based on appearance, as described by Way et al. (2002a). Overall, we identified as many individuals as possible from each study pack, as well as from other groups within the study area.

We classified Coywolves as adults or pups/juveniles. Adults were classified as all full-sized individuals, which likely included yearlings that remained on their natal territory. Behavior (e.g., submission to known adults) strongly implicated many of these helpers as offspring, and research suggests that it is usually yearlings who delay dispersal for a year to remain within their natal range (Patterson and Messier 2001; Way et al. 2002a). Pups were born around 1 April (Way et al. 2001) and were classified as such until October, when they approached full body size and became indistinguishable from adults/yearlings when observed in the field. Therefore, winter density estimates possibly include full-grown pups, as in other canid studies (Mech and Tracy 2004).

To estimate territory sizes, we used Home Range Tools for ArcGIS extension using ArcGIS Version 9.2 (Rogers et al. 2007). Territories were calculated using the 100% and 95% Minimum Convex Polygon (MCP) methods. We used the 95% MCP estimator for all ranges reported herein, except that we combined data from the two breeding resident Coywolves (#0104 and #0103) of the Centerville pack and used that 100% MCP estimator to describe the Centerville pack's territory (Figure 1) (subsequent tracking showed that this best approximated their territory size, i.e., the 100% MCP range bordered other territorial radio-collared packs not reported in this study) (J. Way, unpublished data; Figure 1).

Using Mech and Tracy's (2004) technique, we estimated pack density based on the observed territory and pack size for each of the three packs studied in this paper. Observed pack sizes were divided by their territory size (e.g., 4 Coyotes/2 km<sup>2</sup>) and then converted to densities of individuals per km<sup>2</sup> (e.g., 2 Coyotes/km<sup>2</sup>). A comparison of territory sizes in this paper is made at the pack level and does not incorporate our



entire study area. While we acknowledge that there might have been additional individuals without radio-collars present, such as transients, the same animals without radio-collars were repeatedly observed traveling with radio-marked individuals (see Results). It is likely that any other Coywolves present in these study packs' territories were simply transients passing through the area. These individuals have much larger ranges than the local territory scale discussed in this paper (see Way 2007b). Furthermore, estimating density using this technique for territorial canids is standard in the literature, which typically acknowledges the presence of uncounted transients in a population (Mech and Boitani 2003a, 2003b; Mech and Tracy 2004).

## Results

A total of 48 individual Coywolves (26 males, 22 females) consisting of 11 juveniles (7 males, 4 females), 12 yearlings (8 males, 4 females), and 27 adults (12 males, 15 females) was captured 65 times during our 10-year study. This paper focuses on four of those radio-collared individuals from 2001 to 2008: #0104, #0103, #0203, and #0204, all described in depth below.

Observations of the Centerville pack (Figure 1) began on 20 May 2001, when a thin, lactating, 15-kg female (ID #0104) was captured and radio-collared (see Way 2004 for more background on her). Coywolf #0104 and her probable mate (#0103, an 18-kg adult male captured 22 December 2001) lived in a 19.66 km<sup>2</sup> territory located on both sides of Cape Cod's only major highway (Route 6). They lived in a winter pack size (i.e., after pup/juvenile dispersal) of three or four individuals: we consistently saw three individuals in that pack (20 observations) but made two observations of four individuals traveling together. The fourth individual, which was light-colored, was guessed to be a full-grown pup that was loosely affiliated with the pack and was also observed alone within the pack's territory on three occasions. Density was estimated at 0.15–0.20 individuals/km<sup>2</sup>, with their territory bordering that of other radio-collared packs. We obtained 159 total telemetry fixes for #0104 and #0103 combined before each was hit and killed by cars on Route 6 (#0104 on 8 June 2001 and #0103 on 3 June 2002). Although we tracked #0104 for only one month, her movements encompassed #0103's territory, and previous research has shown that females with pups in our study area travel within their existing territory during the spring and summer (Way et al. 2001, 2002a). Therefore, we felt justified in combining data from Coyotes #0104 and #0103 into their territory estimate.

During summer 2001, the Centerville pack (led by male #0103 and an associate of #0104) raised a litter of four pups (see Way 2004) and we captured and radio-collared one of these pups (#0203, a 15.9 kg male) on 23 February 2002. Up through the month #0103 was killed (i.e., June 2002), #0203 lived in a

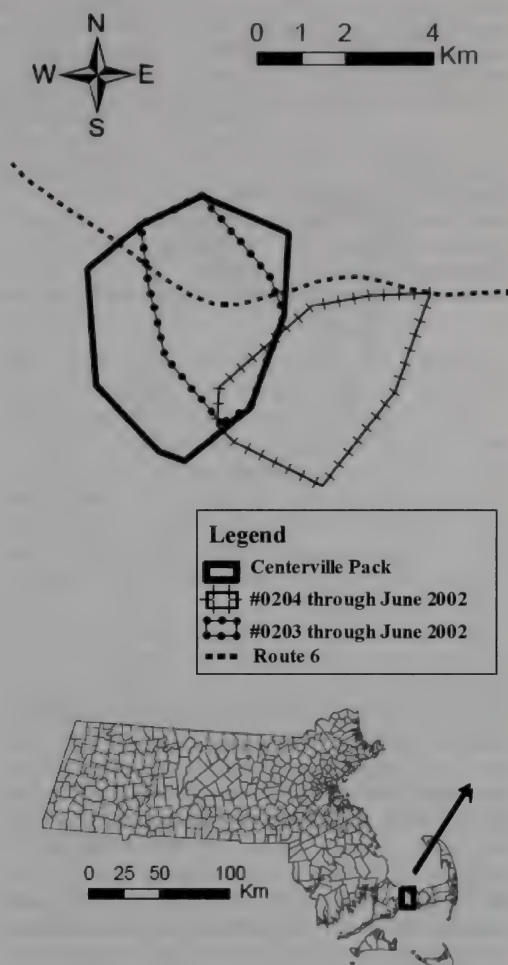


FIGURE 1. Territories for Coywolves on Cape Cod, Massachusetts, through June 2002, when #0103 (part of the Centerville pack) died.

10.46 km<sup>2</sup> area located entirely within the boundaries of the Centerville pack's (i.e., his parent's) territory (Table 1) and was a pack associate/helper. He and male #0103 were frequently located together (see Way 2004) until #0103 was hit and killed by a car in June 2002. Coywolf #0203 was observed acting submissively to his putative father, #0103, as they tended pups in spring 2002. During that same time period, a 13.6-kg yearling female (#0204), captured 6 March 2002 in Cummaquid, was living immediately to the east of the Centerville pack. Coywolf #0204 gave birth to an observed four or five pups during that time period and traveled with one other adult. Up through June 2002, #0204's pack lived in a 12.36 km<sup>2</sup> (95% MCP) territory which had very limited overlap with the Centerville pack's territory (Table 1; Figure 1).

TABLE 1. Proportion of overlap of Coywolf territories in Centerville, Massachusetts. For example, the value 0.0812 (row 2, column 3) should be interpreted as 8.12% of #0204's territory through June 2002 was overlapped by #0203's territory through June 2002. Or the value 0.8569 (row 5, column 3) should be interpreted as 85.69% of #0203's territory after June 2002 was overlapped by #0203's territory through June 2002.

	Centerville Pack	#0204 through June 2002	#0203 through June 2002	#0204 after June 2002	#0203 after June 2002
Centerville Pack	—	0.0548	0.5321	0.5413	0.2684
#0204 through June 2002	0.0872	—	0.0812	0.0585	x
#0203 through June 2002	1.0000	0.0960	—	x	0.4325
#0204 after June 2002	0.8380	0.0570	x	—	0.0488
#0203 after June 2002	0.9994	x	0.8569	0.1174	—

Following the death of #0103 during June 2002, #0203 and #0204 readjusted their territories (Figure 2). Coywolf #0203 decreased the size of his territory almost exactly in half (from 10.46 km<sup>2</sup> to 5.28 km<sup>2</sup>) after #0103's death and stayed mostly north of Route 6, while #0204 maintained virtually the same territory size as before #0103's death (from 12.36 km<sup>2</sup> to 12.70 km<sup>2</sup>), although she shifted her range westward using the southern portion of the Centerville pack's former territory (Figure 2).

Approximately 86% of #0203's new territory (i.e., post-June 2002) overlapped his former one (i.e., through June 2002), whereas only ~6% of #0204's new territory overlapped her former one (Table 1). The new territories of #0203 and #0204 displayed little overlap (~12%), and they essentially subdivided the Centerville pack's former territory in two with #0203 (and his pack) using the northern section and #0204 (and her pack) using the southern section. Specifically, 99.9% and 83.8% of #0203's and #0204's new ranges, respectively, overlapped with the Centerville pack's former territory, and 88% of #0203's and #0204's combined new (i.e., post-June 2002) territories overlapped the Centerville pack's former territory (Table 1).

Coywolves #0203 and #0204 lived as a breeding male and female in each of their respective packs, reproduced in April of each year they were radio-tracked, and lived in a pack size of three or four full-sized individuals. We directly observed both tending pups (and observed #0204 lactating), knew their respective mates by sight (i.e., physical characteristics), and consistently observed both individuals traveling as part of a small pack of three Coywolves on 40 occasions for #0204's pack and 22 times for #0203's pack (a fourth individual in each pack was only occasionally observed; #0203's pack = 4 sightings; #0204's pack = 6).

We estimated a winter density of 0.57–0.76 individuals/km<sup>2</sup> and 0.24–0.32 individuals/km<sup>2</sup> for #0203's and #0204's packs, respectively. The combined density for the two packs post-June 2002 was 0.33–0.45 individuals/km<sup>2</sup>, ~2.2 times greater than the estimate for the Centerville pack. When accounting for the 12% overlap in the outer edge of each pack's territories (i.e., removing that area from one of the pack's territory

sizes; Table 1), Coywolf densities were 0.38–0.50 individuals/km<sup>2</sup> or ~2.5 times greater than the Centerville pack's estimated density.

Coywolf #0203's and #0204's post-June 2002 territories remained consistent for over two and a half years (Figure 2). Coywolf #0203 was located 103 times until his death (gunshot) on 28 February 2005 on his territory, while #0204 was located 1422 times through August 2008 (including two recaptures: 6 May 2006, 16.8 kg; 3 May 2008, 18 kg) on her territory. Coywolf #0204 was still alive (and was still being radio-tracked) as of the completion of this study.

## Discussion

This study documents a more than two-fold increase in local Coywolf pack density in the Centerville area of the town of Barnstable, Massachusetts, following the death of a resident pair of breeding Coywolves. Following the death of the original resident pair, that pack's territory was roughly divided in two; the northern portion was annexed by a beta male member (and his pack associates) of the original Centerville pack and the southern portion was occupied by a pack whose territory formerly bordered, with minimal overlap, on the Centerville pack's territory to the east. While it is difficult to understand the process of how and why these Coywolves subdivided the original territory approximately in half, the data clearly show the multilane highway (Route 6) as the approximate divider. The 12% overlap of the two pack's ranges involved both groups infrequently exploring the other side of the highway (Figure 2).

In order for the density (and, in turn, the population size) of a territorial species such as a Coyote, Coywolf, or Wolf to increase, at least one of the following scenarios must occur: (1) average pack territory size decreases (e.g., Person and Hirth 1991; Mech and Boitani 2003b); (2) average pack size increases (e.g., Way 2003); (3) the number of transient individuals in a population increases (see Way 2007b and sources within); or (4) packs become less territorial, allowing for overlap among territories of neighboring packs (Forbes and Theberge 1995; Mech and Boitani 2003b). The first two scenarios (and possibly the fourth) occur at a local, resident pack(s) scale in canids, depending largely



on the availability of food (e.g., Gese et al. 1996a; Crabtree and Sheldon 1999), while the third scenario occurs over a much greater spatial scale, as the result of the long-distance movements often exhibited by transient canids. Observations detailed in our study support an increase in canid density under scenario 1, where the new packs subdivided the Centerville pack's original territory roughly in half, yet each pack lived at a normal pack size (i.e., three or four individuals) within each small territory.

Gese (1998) documented a similar shift in the territories of resident Coyote packs following the death of an alpha male in Yellowstone National Park (Wyoming, USA), although no increase in Coyote density was observed. One potential explanation for the original territory in our study being divided is the following: subsequent to the death of the breeding male of the Centerville pack (#0103), there was no dominant male remaining to ward off non-pack members (e.g., see Gese 2001), thereby allowing an influx of Coywolves into the area. Similarly, researchers studying Cougars (*Puma concolor*) and Black Bears (*Ursus americanus*) have demonstrated that, in certain instances, killing adult territorial males can cause an influx and hence greater population density of both of these species in a local area (Sargeant and Ruff 2001; Hornocker and Negri 2010: 138, 236, 239).

While not quantified in this paper, the increase in density did not appear to be the result of a change in food availability, as rodents and rabbits comprised the majority of food during both periods (i.e., prior to and following the death of the original resident pair), and there was no noticeable change in the availability of these or other food sources (e.g., anthropogenic sources, domestic cats) in the study area (J. Way, unpublished data). However, more rigorous studies need to better correlate food resources with Coyote/Coywolf density.

This research highlights the need to study carnivores in a diversity of landscape settings over broad temporal scales to elucidate factors causing variability in territory and group sizes. Coyotes and Coywolves are territorial, and this effectively limits their density (Gese et al. 1996a, 1996b; Patterson and Messier 2001; Way et al. 2002a). Therefore, it is likely that there are many factors other than food availability that can influence territory size and population density in a given locale. For instance, there may be a behavioral mechanism whereby transients (either as individuals or in pairs) settle into any vacant territory they can find, even if it is smaller than a typical territory used by a (former) pack or is of suboptimal quality.

Additionally, it is plausible that social factors may serve to reduce dispersal rates in populations suffering above-average mortality rates (Frank and Woodroffe 2001). For example, the social gaps caused by the loss of dominant pack members as the result of control programs or trapping may enable lower ranking animals, which would otherwise disperse (e.g., Gese

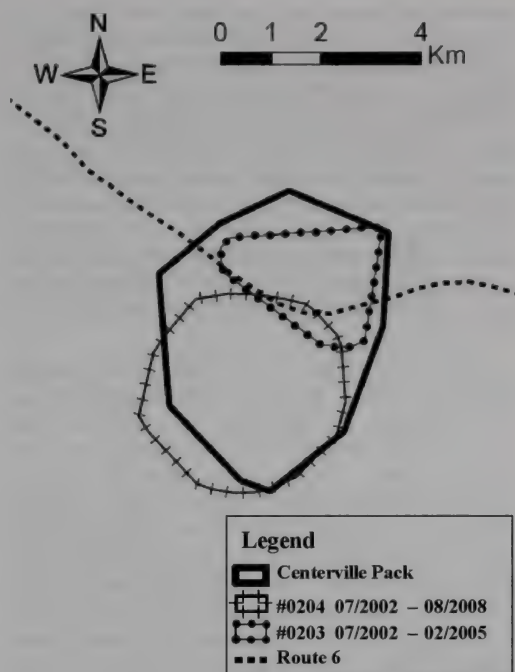


FIGURE 2. Territory of the original Centerville pack (Coywolves #0104 and #0103) until the death of #0103 in June 2002, and territories for #0203 and #0204 after June 2002 on Cape Cod, Massachusetts. Note: #0203 acted as a pack associate (using most of the original range of the Centerville pack) until his putative father, #0103, died.

et al. 1996b), to remain on their natal territory (Frank and Woodroffe 2001; Gittleman et al. 2001). This may be the case with Coyote #0203 in our current study where, after #0203's putative parents (#0104 and #0103; Way 2004) were killed, he was able to remain on a portion of his natal territory as a dominant breeding male.

Future research should monitor the long-term stability of these territories, as was done in this study. For example, if there were a short-term decrease in territory sizes and then an expansion back to one pack in the original territory, the findings of a reduction in the size of the territory would be inconclusive. It is notable in this study, however, that both territories remained small for more than two years after the original pack's dominant male died.

### Management Implications

In areas of low to moderate natural and human-caused mortality, where there is a theoretical abundance of transient Coyotes/Coywolves that have the potential to move into a vacant territory, an unanticipated consequence of control/reduction programs may be a subsequent increase in the density of Coyotes or Coywolves (at least locally, at the pack scale)

following the removal of a breeding male. Under this scenario, there is the possibility that newly colonizing individuals may use smaller areas than the original pack(s), thereby increasing local canid density. Though the mechanisms underlying such shifts to smaller territories are still poorly understood, the occurrence of these shifts in itself is noteworthy, albeit at the small scale (i.e., one pack forming two) observed in this study. There is considerable documentation of transients quickly filling territories left vacant following the death and/or range shift of resident Coyotes and Coywolves (Harrison 1992; Gese 1998; Knowlton et al. 1999; Way 2007b).

If this observed pattern is robust across human-dominated habitats, the potential increased Coyote or Coywolf density that follows territory loss may have significant top-down impacts. Such patterns were observed in Phoenix, Arizona, USA, where the presence of Coyotes increased the foraging activity of songbirds, likely as a result of top-down impacts on feral cats (Adley and Warren, unpublished data). Research similar to ours conducted at larger spatial and temporal scales may provide improved insight into Coyote/Coywolf space-use dynamics and allow for a better understanding of why control programs have historically been inefficient and ineffective (Parker 1995) as well as potentially inhumane and unethical, given the social, intelligent, playful nature of Coywolves (Way 2007a).

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# Observations of Coywolves, *Canis latrans* × *lycaon*, Crossing Bridges and Using Human Structures on Cape Cod, Massachusetts

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I directly observed Coywolves (*Canis latrans* × *lycaon*; also called Eastern Coyote) successfully crossing over rivers/bays by traveling on paved (i.e., used by vehicles) bridges within their established territories. These data confirm that Coyotes/Coywolves use these narrow corridors in their travels, such as when colonizing new areas. I also report on breeding female, sick, and old Coywolves using human structures, including under overturned boats/canoes, under houses, and under sheds/decks. Breeding females ( $n = 3$ ) used these sites as dens, and sick ( $n = 2$ ) and old ( $n = 2$ ) individuals used them for shelter.

**Key Words:** Coywolf, Eastern Coyote, *Canis latrans* × *lycaon*, bridges, buildings, corridors, human structures, movements, urbanized, Cape Cod, Massachusetts.

Coyotes (*Canis latrans*) and Coywolves (*Canis latrans* × *lycaon*; also called Eastern Coyote: Way et al. 2010) are very successful, having expanded their range and colonized offshore islands/peninsulas by using drifting pack ice or wide canals (see Way 2002 and Way 2007 and sources within), bridges (Sacks et al. 2006), and, remarkably, extremely urban New York City (Fener et al. 2005). However, there has not been a direct description of these unique colonization events, as most studies report cause and effect, e.g., a radio-collared individual makes it to the other side of Cape Cod Canal in Massachusetts and is found dead (Way 2002), one shows up in Central Park, New York (see Fener et al. 2005 and sources within), or the genetics of an individual strongly implicate it in crossing the 2 km Golden Gate Bridge into San Francisco, California (Sacks et al. 2006).

Urban Coywolves typically have large home ranges (Way et al. 2002), move daily long distances (Way et al. 2004), and usually den (e.g., under fallen trees or into roots on the side of hills: Way et al. 2001) and sleep (Way et al. 2004) in wooded parts of their territories. In essence, they behave similar to Coyotes and Coywolves from more rural areas (Harrison and Gilbert 1985; Harrison 1992a, 1992b; Patterson et al. 1999; Patterson and Messier 2001) and individuals likely disperse along an urban-to-rural gradient (i.e., they don't restrict themselves to a particular level of urbanization during their lives: Way 2007). Urban Coyotes/Coywolves naturally have many houses/buildings and residential neighborhoods within their territories (Grubbs and Krausman 2009), but use of human structures is not commonly reported (but see Way 2007\*: 87–91). However, Grubbs and Krausman (2009) reported a pack of Coyotes in Tucson, Arizona, USA, using a culvert and utility easement between two rows of houses as den sites and quoted Froman (1961), who

reported dens in culverts under roads with heavy traffic, in basements of abandoned houses, and directly behind a drive-in movie screen.

Here I document (1) direct observations of radio-collared Coywolves using paved bridges located on main roads within the town of Barnstable on Cape Cod, Massachusetts, and (2) Coywolves using overturned boats/canoes, Coywolves under houses, and Coywolves under sheds/decks in Massachusetts.

## Observations of Coywolves Crossing Bridges

I observed Coywolves crossing two bridges (Figure 1). The first bridge (Bridge 1), on South Main Street, separates the villages of Centerville and Osterville. The double-lane (i.e., one lane of traffic going in each direction) bridge is 9.8 m wide, not including 1 m sidewalks on each side, and is 161.5 m long, including 42.7 m of it that goes over the 30.5 m wide Bumps River (the eastern side of the bridge) and 118.9 m of it that goes over a marsh which floods during high tide (the western side of the bridge). It is relatively flat but on a slope going downhill to the west and elevated over the river and marsh. To get to the other side without swimming the river or crossing the bridge, Coywolves would have to travel approximately 1.6 km north to get around the river. This bridge was within the territory of the Craigville pack, consisting at the time of four or five full-sized (i.e., adult/yearling) individuals, two of which were radio-collared.

The second bridge (Bridge 2), located on Bridge Street in the village of Osterville, is a drawbridge (i.e., it opens for passing ships). It goes over a river channel 68.6 m wide that separates North Bay from West Bay, with the bridge providing road access and connecting to the island of Oyster Harbors. The bridge is 131.1 m long from where Coywolves enter and exit the bridge area and has a distinct hump-like shape,



TABLE 1. Details of observations of Coywolves crossing two bridges within the town of Barnstable on Cape Cod, Massachusetts.

Date	Time	Number sighted <sup>1</sup>	Light level <sup>2</sup>	Comments <sup>3</sup>
<b>Bridge 1</b> —South Main Street, separating the villages of Centerville and Osterville				
29 December 2008	23:07	3 (1)	N	Car off in distance; <i>Cost</i> leads the three across.
28 May 2009	06:39	2 (1)	C/D	Light out (just after dawn); <i>Ice</i> and a reddish uncollared Coywolf return to <i>Cost</i> 's den.
3 June 2009	06:05	1 (1)	C/D	<i>Ice</i> crosses bridge while it is light out (early AM).
30 October 2009	00:02	4 (2)	N	A most impressive sighting of four adults (including <i>Ice</i> and <i>Cost</i> ) traveling together within 3–4 m of my truck.
<b>Bridge 2</b> —Bridge Street in the village of Osterville				
30 June 2008	23:07	2 (1)	N	Took 87 minutes from initial observation to cross the bridge ( <i>Mill</i> and the uncollared Coywolf stayed localized nearby).
20 July 2008	00:08	1 (1)	N	SUV approaches and brakes as <i>Mill</i> crosses bridge and runs under guard rail to escape.
24 July 2008	01:01	2 (1)	N	<i>Mill</i> and companion stop and look both ways before crossing over drawbridge.
20 December 2008	00:07	2 (2)	N	<i>Mill</i> and <i>Eb</i> jump over guard rail on ~20 cm of snow, stand on road for ~10 seconds looking around, then cross bridge together.
14 April 2009	19:31	1 (1)	C	<i>Mill</i> crosses bridge at dusk to return to his mate's ( <i>Eb</i> ) den.
2 September 2009	20:22	1 (1)	N	<i>Eb</i> turns away six times in 41 minutes before crossing with no cars approaching.
19 February 2010	22:26	2 (2)	N	<i>Eb</i> and <i>Mill</i> travel together side by side across.

<sup>1</sup>Number of Coywolves observed crossing bridge with number of radio-collared Coywolves in parentheses.

<sup>2</sup>N = Night/dark, C = Crepuscular (dawn/dusk), D = Daytime.

<sup>3</sup>Radio-collared individuals: *Cost*—15-kg breeding female; *Ice*—18.8-kg young male; *Mill*—19.6-kg breeding male; *Eb*—16.5-kg breeding female.

including a grate 14.9 m long  $\times$  7.6 m wide at the crest. This grate allows the bridge to open for boats. On both sides of the bridge, there are narrow sidewalks 0.5 m wide and guard rails which are 33 cm and 63.5 cm from ground level to the bottom and top rails, respectively. This bridge is within the territory of the Osterville pack, which consisted of four or more individuals (two of which were radio-collared) during mid-winter (Figure 1).

During observations of bridge crossings, I positioned myself at a vantage point where I could see the bridge from my parked vehicle with the engine and lights turned off that was far enough away so that I would not disrupt animal movements. I used radio-telemetry gear to detect when radio-collared individuals were nearby, and both bridges had overhead street lights which aided my observations with binoculars.

I made 11 observations of Coywolves crossing these bridges, with 4 of the sightings on Bridge 1 and 7 on Bridge 2 (Table 1). Between 1 and 4 Coywolves were observed crossing bridges at the same time (mean = 1.9), and all observations involved one or two individuals that were equipped with a radio-collar. Eight of the sightings occurred at night, one at dusk, and two post-dawn, when it was fully light outside (Table 1).

These bridges connect mainland sites and nearby small islands on Cape Cod. This paper provides veri-

fication of Coywolves traveling on paved bridges. Based on the behavior of these animals crossing the bridges (e.g., looking both ways before crossing and their familiarity with the area), this was probably a regular occurrence for both of these two packs as they traveled through their sizable territories (Figure 1). Way and Eatough (2006) noted Coywolf use of micro-corridors (e.g., hole/opening in fence) in a heavily urban area. Similarly, this paper details Coywolves using small, linear corridors (i.e., bridges), and provides evidence that the species probably uses these structures to aid in its colonization of seemingly disparate areas in its expanding geographic range (e.g., see Way 2002; Fener et al. 2005; Sacks et al. 2006).

### Use of Urban Structures

I documented three breeding female Coywolves that gave birth under human structures. On 12 April 2002, I found a litter of nine ca. 25-day-old pups under a shed in a highly residential area (~0.1 ha lots) in downtown Falmouth (see Way 2007\*). The mother, which was not radio-collared, was fed by people. She slept in backyards and used sheds and decks in multiple years (personal communication, Falmouth Department of Natural Resources).

On 28 March 2007, I observed a radio-collared 18.6 kg female denning under an overturned rowboat



FIGURE 1. Location of the two bridges described in this paper with 1 km grids as scale. Territory size of Osterville pack is shown on this topographical map to illustrate how Bridge 2 connected their otherwise fragmented territory. The Centerville pack's territory bordered the Osterville pack's eastern boundary and went east off the map. Hence, Bridge 1 is in the southwestern part of the Centerville pack's territory.

about 5 m from a house at the northeastern edge of Long Pond in Centerville, within the town of Barnstable. I heard an unknown number of pups whimpering and observed the female nursing them. The residents of the house did not know she was there.

On 18 March 2009, I observed a 14.6-kg radio-collared female leave the general area of a canoe when I approached from a backyard on Bay View Road on the north side of Scudder Bay in Centerville. I saw two newborn pups under the overturned canoe, which was 50–75 m south of two houses. No adult Coywolves other than the breeding females were observed using these structures. The two mid-March whelping dates are about two weeks earlier than reported by Way et al. (2001) from the same study area.

I observed a total of four instances of sick ( $n = 2$ ) and old ( $n = 2$ ) Coywolves using human structures. In mid-June 2002, I found the remains of an 11-year-old 17.7-kg female dead under a shed separating two cranberry bogs (Way and Strauss 2004\*). She had been located > 400 times and had never been documented using a human structure until her last (i.e., death) location (note: I did not track her for about 6 months before her death: see Way 2007\*: 90).

On 18 February 2003, my colleagues and I tracked a 14.5-kg male with severe mange in the town of Saugus (north of Boston) to a wooded area that had a pile of plywood in 45 cm of snow. We saw two or three fresh sets of tracks leaving the area when we approached, but we located the radio-collared male in a plywood-like den in the wood pile. It appears that his pack mates, none of whom had mange, were bedded nearby while he was resting in a dry area (see Way 2007\*: 88–89). The Coywolf ended up starving to death in March 2003 despite our leaving food/bait for him (Way 2007\*).

I radio-tracked a large 25-kg breeding female (see Way and Proietto 2005) from 1998 to 2004 in the village of Cummaquid. The animal's behavior changed dramatically in January 2005, when, during a two-week period, 90 cm of snow fell. She was located on six occasions sleeping under sheds and/or decks in highly residential neighborhoods at the southeastern edge of her range. Most of these locations were in unoccupied summer houses. She had recently been displaced from (or had vacated) her breeding role and was nomadic until she was shot and killed in early February 2007 (Way and Timm 2008).



During observations from 22 to 25 November 2005, I saw a thin, young 14.5-kg radio-collared male come out from under a porch in a summer home (i.e., unoccupied at the time) in the town of Mashpee on Old Brickyard Road at the southeastern part of John's Pond. A house 50 m away was occupied by people, and there were many houses (~0.1 ha lots) in this neighborhood. He was sick, with shotgun pellets lodged inside his body (determined by X-ray after he died), neck chafing from the collar, and a slight case of mange. He left the house at night and returned during the daytime during those four days. In addition, on 4 December 2005, this animal spent one or two days under a shed at the southeastern part of Ashumet Pond ca. 1 km west of the November house. He was found dead on 22 December 2005 in the general area.

My presence/disturbance was enough to move Coywolves out of these structures, even though I tried to minimize my impact to avoid bothering/moving my study subjects. However, simply disturbing the area would likely have caused all animals to move to alternate locations, similar to breeding females moving dens upon disturbance (Way et al. 2001). In other words, our actions (e.g., either disturbing or leaving the area alone) will likely teach individual Coyotes/ Coywolves about the habitability of a particular location. While Coywolves typically prefer shelter in more wooded areas of their territories (Way et al. 2001, 2004), these accounts indicate that breeding females, sick, and old individuals do occasionally use residential areas/human structures for security, especially summer homes with little human activity. As successive generations of wild animals became increasingly used to living in urbanized areas, use of human structures by wild animals may become more commonplace as these objects may simply be viewed as a natural part of their landscape (i.e., habitable). Managers should prepare for these occurrences and educate the public about Coyote/Coywolf ecology and behavior and ways to avoid or minimize conflicts, such as accepting the presence of these animals (i.e., coexistence) or encouraging Coywolves to find a new shelter by disturbing the area.

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# Comparison of a Population of Eastern Red-backed Salamanders, *Plethodon cinereus*, under Native Dominant Wood Coverboards and Natural Cover Objects

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Artificial cover objects or coverboards have been widely used to study Eastern Red-backed Salamanders (*Plethodon cinereus*), a species that is very abundant in eastern North America and known to be one of the most common vertebrates within its geographical range. However, recent studies have suggested that potential bias may be associated with the use of coverboards compared with natural cover objects. In this study, age structure and body size (weight and snout-vent length, SVL) of *P. cinereus* found under coverboards and natural cover objects at Lake Clair (Quebec, Canada) were compared. Coverboards were made of Sugar Maple (*Acer saccharum*), a native forest species dominant in the study area. In 2004 and 2005, a total of 162 *P. cinereus* were found under coverboards, and 156 *P. cinereus* were found under natural cover objects. No significant difference in the age structure, mean weight, or SVL of *P. cinereus* was observed between the two sets. This study suggests that the type of coverboard used at Lake Clair is a good method to obtain an accurate index of *P. cinereus* population demographics, and is similar to that expected under natural cover objects. This technique should help to establish a standard protocol that could better allow direct comparisons among studies in the future. However, more studies are needed to explain the high proportion of adult specimens found under both cover types at Lake Clair relative to studies in other regions in North America.

**Key Words:** Eastern Red-backed Salamander, *Plethodon cinereus*, capture comparison, wood coverboards, natural cover objects, northern hardwoods, Lake Clair, Lac Clair, Quebec.

The Eastern Red-backed Salamander (*Plethodon cinereus*) is a terrestrial species widely distributed in forests of eastern North America (Conant and Collins 1991). In many of these ecosystems, *P. cinereus* is probably the most abundant salamander (Burton and Likens 1975; Jaeger 1980) and terrestrial vertebrate (Burton and Likens 1975). Moreover, this salamander may play an important role within the food web of these forests, where they are consumers of small invertebrates (Burton and Likens 1975; Wyman 1998). In recent decades, many studies have demonstrated that these salamanders may also be good indicators of forest disturbance (deMaynadier and Hunter 1995; Patrick et al. 2006) and of changes in forest microhabitats (Wyman and Hawksley-Lescault 1987; deMaynadier and Hunter 1998).

Artificial cover objects or coverboards have been widely used to sample *P. cinereus* (cf. Moore 2005 for a review) because they may simulate downed woody debris, an important habitat component for *P. cinereus* (Heatwole 1962; Test and Heatwole 1962; Grover 1998). Other advantages of this technique include reduced habitat disturbance, modest time and labour costs, standardization of the number and area of cover items, and little between-observer variability (Fellers and Drost 1994). However, few studies have investigated how sampling using coverboards equates to population demographics found under natural cover objects (Monti et al. 2000; Marsh and Goicochea 2003). Marsh

and Goicochea (2003) suggested that potential bias among size classes of *P. cinereus* may be associated with the use of coverboards as compared to natural cover objects.

Previous studies in the Lake Clair watershed show that using native dominant wood species as coverboards is a very efficient technique to sample *P. cinereus* (Moore 2005). However, whether sampling using coverboards represents the true population at Lake Clair is unknown. The objective of this study was to try and answer this question by comparing population demographics (snout-vent length (SVL), weight, and age structure) of *P. cinereus* found under coverboards and natural cover objects in this ecosystem.

## Study Site

The Lake Clair watershed (226 ha, 46°57'N, 71°40'W, elevation 270 to 390 m) is located approximately 50 km northwest of Québec City, Quebec, Canada. Forest vegetation is dominated by uneven-aged deciduous species (83%) with small patches of conifers (17%). The deciduous area is composed of Sugar Maple (*Acer saccharum* Marsh.), Yellow Birch (*Betula alleghaniensis* Britton), and American Beech (*Fagus grandifolia* Ehrh.). The coniferous area includes principally Balsam Fir (*Abies balsamea* (L.) Mill.) and a much lower proportion of Red Spruce (*Picea rubens* Sarg.) and White Birch (*Betula papyrifera* Marsh.). Soils are classified as Orthic Ferro-Humic Podzol (Canada



Soil Survey Committee 1998) or Typic Haplorthod (Soil Survey Staff 1998). The humus is a mor-moder type, and the surface deposit is a very acidic and stony glacial till derived from granitic gneiss bedrock. Average slope is approximately 10%. Mean annual temperature is 3.4°C and annual precipitation is 1300 mm.

## Materials and Methods

### Sampling

In September 2001, 13 transects of 100 or 200 m in length were established around the lake, perpendicular to the lake shore, with a minimum distance of 300 m between each transect. Coverboards were placed along each of these transects at predetermined intervals from the lakeshore (0, 5, 10, 20, 40, 60, 100, 150, 200 m). Boards were placed on the transect line, on the nearest upper-soil surface available. A total of 104 coverboards were placed during this operation. Coverboards were constructed from radial sections of Sugar Maple trunks. Boards were 4 cm thick; the diameter varied from 36 to 42 cm and the surface area varied from 855 to 1400 cm<sup>2</sup>.

Coverboards were checked during daylight hours, on a single rainless day (sunny or cloudy), four times in each of 2002, 2003, 2004, and 2005, from the end of May through mid-October. Only the 2004 and 2005 sampling years were used in this study. Natural cover objects were checked in 2004 and 2005. They consisted of woody debris of different sizes, species (Sugar Maple, Yellow Birch, American Beech, Balsam Fir, Red Spruce), and degree of decomposition (solid wood to very decayed). Also, bark pieces on the soil surface, mainly from Sugar Maple trees, were checked. The surface area of 55 woody debris and bark pieces was measured. They varied in size from 5 to 55 cm in width, 10 to 400 cm in length, and 45 to 13 700 cm<sup>2</sup> in surface area.

Salamanders were first sampled under coverboards. To generate a relatively similar sampling size for both sampling methods (for comparison purposes), when *P. cinereus* was found under a coverboard, natural cover objects in a parallel area situated 15 m from the coverboard finding were checked for salamanders, based on how many salamanders were found under coverboards. Parallel sampling was done the same day or within a few days. Sampling effort was not noted, but it did not exceed 10 minutes for each parallel sampling.

Snout-vent length was measured in the field to the nearest 0.1 mm using a dial calliper. Salamanders were weighed to the nearest 0.1 g with a 10 g Pesola® spring scale. This type of balance has been widely used in other studies and monitoring programs to weigh lightweight salamanders (Anonymous 1999\*; Gustafson et al. 2001; Zorn et al. 2004\*; Moore 2005; Crawford and Semlitsch 2008). No attempt was made to deter-

mine the gender of animals. Salamanders were handled in a transparent plastic bag that had previously been sprayed with lake water. After measurement, salamanders were immediately released at the edge of the coverboard or natural cover object under which they had been found. More information on methods can be found in Moore (2005).

### Stage classes used

Many age structures have been proposed to categorize *P. cinereus* populations (Blanchard 1928; Test and Bingham 1948; Heatwole and Heatwole 1962; Saylor 1966; Bonin et al. 1999; Marsh and Goicochea 2003; Leclair et al. 2006). The structure proposed by Marsh and Goicochea (2003) in Virginia was used in this study (young of the year (< 25 mm), juvenile (25–32 mm), and adult (> 32 mm). It appeared to provide the best fit for the *P. cinereus* population at Lake Clair, as eggs were observed in some female *P. cinereus* of approximately 32 mm (SVL), indicating sexual maturity at this length. Moreover, this age structure is very similar to that which Bonin et al. (1999) used to study *P. cinereus* in southern Quebec.

### Statistics

Analysis of variance (ANOVA) was employed to compare surface areas of natural cover objects and coverboards and to compare body parameters of the three developmental stage classes (adult, juvenile, and young of the year) of *P. cinereus* found under the two types of covers. The GML model procedure in SAS (SAS Institute 2008) was used. Frequency analysis was performed to compare the number of *P. cinereus* in each stage class found under natural cover objects and coverboards. Also, correlation analysis was used to evaluate the relationship between the surface areas of coverboards and natural cover objects and the three characteristics of *P. cinereus* (weight, snout-vent length, and total length). Outlier analysis and normality of the data were assessed with residuals.

## Results

A total of 162 *P. cinereus* (four of the lead colour phase) were found under coverboards in 2004 and 2005. Weight of salamanders varied from 0.05 to 1.60 g, and SVL varied from 11.66 to 48.55 mm. Mean weight and mean SVL were 0.86 g and 39.30 mm, respectively. During the same period, 156 *P. cinereus* (eight of the lead phase) were found under natural cover objects. Weight of salamanders varied from 0.05 to 1.85 g, and SVL varied from 17.81 to 49.92 mm. Mean weight and mean SVL were 0.88 g and 40.47 mm, respectively.

Year-to-year variations were noted, all cover types combined, for the weight of all the stage classes combined and for adults only ( $P \leq 0.032$ ), but not for juveniles and young of the year ( $P > 0.413$ ). However, no interaction between the year and cover type was detected for weight and SVL for all the stage classes

combined and each of the stage classes ( $P > 0.072$ ). Also, no year-to-year variation was noted for SVL ( $P > 0.440$ ).

Differences between mean surface areas ( $\pm$  standard error) of coverboards ( $1130 \pm 157 \text{ cm}^2$ ) and mean surface areas of natural cover objects ( $2562 \pm 220 \text{ cm}^2$ ) were highly significant ( $P < 0.001$ ). However, no relationship was found between the surface area of coverboards and natural cover objects and the weight ( $P \geq 0.115$ ) and SVL ( $P \geq 0.455$ ) of *P. cinereus* during the two-year sampling period. The effect of year ( $P \geq 0.061$ ) and season ( $P \geq 0.098$ ) was also not significant.

Over the two-year sampling period, only a slight difference in mean SVL for all *P. cinereus* (all stage classes combined) was detected between the two cover types (Table 1;  $P = 0.043$ ). However, this difference was very small (the SVL of salamanders under coverboards was 39.22 mm, and the SVL of salamanders under natural cover objects was 40.44 mm). No significant difference was observed within stage classes ( $P \geq 0.074$ ) or mean weight ( $P \geq 0.39$ ) between *P. cinereus* found under coverboards and salamanders found under natural cover objects (Table 1).

The proportions of *P. cinereus* with cut tails captured under coverboards (4.9%, 8 out of 162) and natural cover objects (3.2%, 5 out of 156) were not significantly different ( $P = 0.819$ ).

Discussion

Salamander size versus cover size

No relationship was found between the surface area of the two board types and the sizes of *P. cinereus*, despite the wide range in the surface area of natural cover objects (45 to 13 700 cm<sup>2</sup>). Previous study in 2002 and 2003 in the same experimental design also shows the same pattern for the coverboards (Moore 2005). Also, similar results were found in Virginia (Faragher and Jaeger 1997: coverboard surface area range of 10 to 5000 cm<sup>2</sup>; Gabor 1995: coverboard surface area > 50 cm<sup>2</sup>). Other studies found, however, that size or weight of *P. cinereus* was correlated with cover item size (Mathis 1990; Moore et al. 2000); in these cases, cover size effect was attributed to seasonal influence. This was, however, not the case at Lake Clair.

Salamander size versus cover type

Over the two-year sampling period, results of this study show that no important difference exists between the weight and SVL of salamanders found under coverboards and natural cover objects, even though the mean surface area of the natural cover objects was more than double that of the coverboards. These results are similar to several studies which found that salamanders found under coverboards were similar in size to those found under natural cover objects (Monti et al. 2000; Houze and Chandler 2002). However, they differ from the results of Marsh and Goicochea (2003), who reported that in a mature hardwood forest of Vir-

TABLE 1. Comparison of age structure of Red-backed Salamanders found under coverboards and natural cover objects at Lake Clair in 2004 and 2005. Number in parentheses is standard error; SVL = snout-vent length.

Age class	SVL class (mm)	Found under coverboard				Found under natural cover objects				P value (coverboard vs. natural cover objects)		
		n	%	Mean weight (g)	Mean SVL (mm)	n	%	Mean weight (g)	Mean SVL (mm)	n	Mean weight	Mean SVL
Young of the year	< 25	2*	1.2	0.05 (0.08)	14.21 (2.79)	3	1.9	0.19 (0.06)	22.50 (2.41)	0.655	0.390	0.266
Juvenile	25 – 32	14	8.6	0.43 (0.03)	29.82 (0.54)	6	3.8	0.40 (0.05)	28.93 (1.07)	0.074	0.627	0.466
Adult	> 32	146	90.1	0.92 (0.02)	40.59 (0.32)	147	94.2	0.91 (0.02)	41.29 (0.31)	0.907	0.853	0.119
All		162		0.86 (0.02)	39.22 (0.42)	156		0.88 (0.02)	40.44 (0.42)		0.572	0.043

\*Fifteen freshly hatched Red-backed Salamanders were found under a simple coverboard in September 2005 and were not included in this table.



ginia, there were more adult and fewer juvenile and hatchling *P. cinereus* under coverboards than under natural cover objects.

It may be possible to account for the difference observed between the two studies. First, relatively high variability exists between the spring and fall 2001 surveys in Marsh and Goicochea's (2003) study. For example, fewer juvenile *P. cinereus* were captured in the spring survey from under coverboards than under natural cover objects (27 vs. 58), but more juveniles were captured in the fall from under coverboards than under natural cover objects (22 vs. 11). Second, many differences exist between the materials and methods of the two studies (e.g., age of coverboard, type of natural cover objects and coverboards, humus type, sampling period, sampling time). This last point highlights the need to establish standard protocols that could better allow direct comparisons of *P. cinereus* data among studies in the future, regardless of where they are conducted.

#### Adult proportion

The mean adult proportion for both cover types was relatively high at Lake Clair (92%, 293 out of 318; Table 1) compared with other studies (Blanchard 1928: 70%, > 32 mm; Test and Bingham 1948: 49%, ≥ 34 mm; Saylor 1966: 80%, > 32 mm; Nagel 1977: 72%, > 32 mm; Faragher and Jaeger 1997: 74%, ≥ 34 mm; Bonin et al. 1999: 74%, > 32 mm; Marsh and Goicochea 2003: 46%, > 32 mm). Marsh and Goicochea (2003) proposed some hypotheses to explain the greater proportion of adults under coverboards than under natural cover objects. For instance, they mention that (1) adults may prefer coverboards to natural cover objects and (2) adults may be more evenly dispersed than juveniles and may move into the new habitat represented by coverboards. This would not explain the high proportion of adults under both wooden cover types in the Lake Clair watershed. A possible explanation for this phenomenon could be low recruitment of *P. cinereus* at Lake Clair compared to other studies.

Another possible explanation is that juvenile *P. cinereus* could be more abundant in the forest floor of this forest ecosystem, where abundant leaf litter is present (given the absence of foraging and litter-consuming earthworms). In northwestern Pennsylvania, Moore et al. (2000) found that the size and weight of *P. cinereus* were significantly greater for individuals captured under rock and downed wood than in leaf litter. In other studies, authors suggested that adult *P. cinereus* may tolerate the presence of juveniles in their territories (Jaeger et al. 1995; Faragher and Jaeger 1997). Also, Jaeger et al. (1995) observed territoriality in adult *P. cinereus* but not in juveniles. In this context, more studies will be needed to explain the high proportion of adult *P. cinereus* at Lake Clair.

#### Predation or conspecific aggression

The proportion of *P. cinereus* that had a cut tail was similar for both cover types (coverboard 4.9%; natu-

ral cover objects 3.2%). These proportions are lower than those found in other parts of Quebec, where Bonin et al. (1999) reported a cut tail rate between 0 and 35% (mean = 9.8%) among the 27 forests studied. These authors also found that cut tail rate was inversely correlated with the amount of woody debris on the forest floor. This suggests that the forest floor habitat of the Lake Clair watershed provides sufficient shelter for salamanders to allow *P. cinereus* to avoid important conspecific aggression (Jaeger 1981) or predation. Sugar Maple has been declining for more than a decade in the Lake Clair watershed (Duchesne et al. 2003), resulting in a relatively large volume of woody debris on the forest floor. The abundance of leaf litter in this ecosystem may also play a role by providing shelter during the displacement or dispersal of salamanders.

#### Conclusion

This study suggests that the type of coverboard (made of wood from a native dominant forest species) used at Lake Clair is a good method to obtain indices of *P. cinereus* population demographics similar to those of salamanders found under natural cover objects. This technique should help to establish a standard protocol that could better allow direct comparisons among studies in the future, regardless of where they are conducted.

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# The Ecology of Red Foxes, *Vulpes vulpes*, in Metropolitan Toronto, Ontario: Disease Management Implications

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During 1989–1992, 33 Red Foxes (*Vulpes vulpes*) were fitted with radio-collars in metropolitan Toronto to study their behaviour which would provide data to assist with the design of a rabies control strategy for urban areas of Ontario. Annual home range size for adult foxes ( $\bar{x}$  = 325 ha, SD = 207) was significantly larger than that of juvenile foxes ( $\bar{x}$  = 165 ha, SD = 176), but we could not detect any seasonal differences in home range size for foxes. Mean (SD) nightly ranges were 38.3 ha (48.3) in spring, 97.4 ha (115.4) in summer, 26.8 ha (28.5) in fall, and 16.3 ha (13.6) in winter. Movements by foxes during the period from June to November averaged 3.5 km (2.89). Eleven of the foxes were known to have dispersed ( $\geq$  3 km from their home range), but we could not detect a mean direction of dispersal. Thirty-six percent (4/11) of the foxes dispersed in December and 18% (2/11) dispersed in August, with the remainder dispersing between February and November. Average dispersal distance was 19.3 km (15.6), and a significant negative correlation was detected between initial home range size and dispersal distance of foxes. Mortality of radio-collared foxes was caused by collisions with automobiles, predation, and shooting. Foxes made extensive use of ravines and other greenbelt areas, such as parks and golf courses. Residential areas were also used by some foxes. Knowledge of the habitats frequented by foxes as well as their movement potential assisted researchers in determining where vaccine baits should be placed for the control of rabies in Red Foxes in metropolitan Toronto.

**Key Words:** Red Fox, *Vulpes vulpes*, home range, movements, metropolitan Toronto, Ontario.

Rabies was prevalent in Red Foxes (*Vulpes vulpes*) in rural habitats of Ontario (Voigt 1987) as well as in some urban complexes such as metropolitan Toronto, Ontario, during the 1960s through the 1980s (Rosatte et al. 1992). During the 1970s, Voigt (1987) used radio-telemetry to study the ecology of Red Foxes in southern Ontario. That ecological data assisted researchers in developing an aerial vaccine-baiting system for the control of rabies in rural habitats of the province (MacInnes et al. 2001). This control program, which used Twin Otter aircraft to distribute vaccine baits over large contiguous areas, was not feasible for urban landscapes with high human population levels and very fragmented fox habitat. A radio-telemetry study of urban fox ecology was initiated in metropolitan Toronto in 1989 to provide data to help design a rabies control strategy for urban foxes.

## Study Area

The study area consisted of a 1000 km<sup>2</sup> urban complex known as metropolitan Toronto, Ontario, Canada, centred at 43°42'N, 79°26'W [see Rosatte et al. (1992) for a map of the study area]. At the time of the study, this urban complex consisted of the cities of North York, Etobicoke, Scarborough, Toronto, and York and the borough of East York. The study area also included the city of Mississauga. The human population at the time (circa 1989) was estimated at approximately 2.5 million (about 4200 people/km<sup>2</sup>) and the landscape was composed of multiple land-use classes, including

residential, industrial, commercial, and greenbelt areas [see Rosatte (1986) and Rosatte et al. (1992) for complete description and habitat maps]. The urban complex was intersected with a number of ravine systems associated with waterways, including the Credit River, the Humber River, Etobicoke Creek, the Don River, Highland Creek, and the Rouge River [see Rosatte et al. (1992) for a map of river systems].

## Methods

During 1989–1990, a total of 33 Red Foxes were live-captured from 13 different areas in metropolitan Toronto using humane Novak foot snares and Tomahawk #108 double door cage traps (Tomahawk, Wisconsin). Traps were placed in habitats wherever fox sign (e.g., tracks, scat) was evident. The procedure following capture included chemical immobilization using a mixture of ketamine hydrochloride and acepromazine and vaccination with an intramuscular injection (1 mL) of Imrab inactivated rabies vaccine (Merial Inc., Athens, Georgia). The fox was fitted with a VHF radio-collar (148–152 MHz, Lotek, Newmarket, Ontario) and released at the point of capture. Animals were located on the ground as well as from Cessna aircraft with Lotek SRX 400 receivers and Yagi antennae during the period 1989 to 1992. Locations of foxes were calculated by the intersection of two or three compass bearings (triangulation) from the observer to the fox location and were plotted on topographical maps. Foxes were located during the day as well as at night.

Home ranges using a kernel estimator were calculated using Ranges IV and V software. An estimate is provided for annual and seasonal ranges of foxes using the total number of fixes. A minimum of 25 fixes were required for annual home range analysis (using area-observation curves), and at least three months of tracking data were required for seasonal range calculations. Dispersal fixes were not included in home range calculations and were defined as a movement of  $\geq 3$  km from the home range; this distance was considered a significant movement, given the small home ranges reported for urban foxes in previous studies (Trehwella et al. 1988).

Home ranges were determined for the following seasons: spring (March–May), summer (June–August), fall (September–November), and winter (December–February). Foxes were tracked continuously during the evenings during each month to obtain an estimate of nightly range. The number of continuous tracking locations varied, from one location every 20 minutes to one location every 2 hours. Timing of dispersal of foxes was also determined in order to provide data on family unit separation.

This study occurred during a three-year period from July 1989 to July 1992. Adkins and Stott (1998) documented some of the movements of seven of these foxes over a three-month period during the summer/fall of 1990 as part of a graduate student program at Queen's University, Kingston, Ontario. Those data are included in our study.

Data were analyzed using Statistica 6.0 software. A repeated measures ANOVA was used to determine whether there were age (adults vs. juveniles) and sex (males vs. females) differences in home range. A Student's *t*-statistic was used to examine the data for sex and age differences in dispersal distances and nightly movements of foxes during spring and fall. Rayleigh's Test of Uniformity was applied to the movement data to determine whether the circular distribution of dispersal angles was uniform (Zar 1999).

## Results

**Annual/seasonal home ranges:** A total of 3788 location fixes were acquired on 33 radio-collared foxes during 1989–1992. Four of the foxes were excluded from the analyses of annual home ranges because there were too few fixes ( $< 25$  fixes because the transmitter malfunctioned, the animal died, or the signal could not be located). A juvenile male fox (T9017) that dispersed twice and did not settle down (resulting in an annual range  $> 182$  km<sup>2</sup>) was also excluded from the range analysis.

The mean number of location fixes for annual home range analysis for the 29 foxes was 129.3 (SD = 117.6). Annual home range size (using day and night fixes) for adult foxes ( $\bar{x}$  = 325 ha, SD = 207; range 114–718 ha) was significantly larger than that of juvenile foxes ( $\bar{x}$  = 165 ha, SD = 176; range 21–541 ha) ( $P$  = 0.02)

(Table 1) during the study. However, no differences were found between annual home ranges of males and females ( $P$  = 0.89), adult males and adult females ( $P$  = 0.59), or juvenile males and juvenile females ( $P$  = 0.23) (Table 1). We could not detect any differences in seasonal home ranges of foxes ( $P$  > 0.05) (Table 1).

A juvenile male fox (T9017) was collared and released in Warden Woods Park, Scarborough, on 3 August 1990. It spent the fall and winter in a confined area, then dispersed ( $> 4$  km from its home range) in March and April 1991. He then settled down in one area for the summer of 1990. Overall, the annual [18 285 ha (182.9 km<sup>2</sup>)], spring [13 984 ha (140 km<sup>2</sup>)], and summer [1677 ha (17 km<sup>2</sup>)] ranges were exceptional; however, the fall range was more comparable to an urban fox [18.1 ha (0.18 km<sup>2</sup>)].

**Nightly ranges:** Twenty-two foxes were monitored between 1 and 19 nights (4 to 8 hours/night) (1989 and 1990) when they were active (total of 54 nights for all foxes). Mean (SD) nightly ranges were 38.3 ha (48.3) in spring ( $n$  = 7 nights); 97.4 ha (115.4) in summer ( $n$  = 11 nights); 26.8 ha (28.5) in fall ( $n$  = 35 nights); and 16.3 ha (13.6) in winter ( $n$  = 4 nights). Summer ranges were significantly larger than fall ranges ( $P$  = 0.001).

**Nightly movements:** Nightly movements during June to November, 1989 and 1990, for 21 of the above noted foxes [an adult female (T8905) with kits was excluded from these calculations] averaged 3.5 km (SD = 2.89, range 0.3–11.1 km;  $n$  = 35 nights). No significant differences ( $P$  = 0.09) were detected between nightly movements in the summer ( $\bar{x}$  = 4.7 km, SD = 3.1; range 0.9–11.1 km) vs. the fall ( $\bar{x}$  = 2.9 km, SD = 2.7; range 0.3–9.9 km). Sample size was too small to compare nightly movements during winter and spring. One of the foxes, an adult female with kits (T8905), was monitored for 19 nights (1800 to 0600) between 21 March and 13 December 1990. Nightly movements ranged from 0.3 km to 5.4 km (Figure 1). However, mean nightly movement ( $\bar{x}$  = 2.3 km, SD = 1.6; range 0.3–5.4 km) during the parturition/kit rearing months (March and April) was significantly greater than mean movements from September to December 1990 ( $\bar{x}$  = 0.85 km, SD = 0.47; range 0.1–1.4 km) ( $P$  = 0.011) (Figure 1). When she was monitored for a week during late March 1990, T8905 used a different part of her range during each evening.

**Dispersal:** Data were collected on 32 foxes with sufficient information to determine that 25 of those either dispersed ( $\geq 3$  km from their home range) or did not (it is possible that the other 7 that could not be located dispersed). Eleven of the 25 (44%) dispersed from the area in which they were radio-collared. Average dispersal (SD) distance for those was 19.3 km (15.6) (range 5–48 km) (Figure 2). There were no age or sex



TABLE 1. Mean (SD) annual and seasonal home ranges (ha) for Red Foxes in metropolitan Toronto during 1989 to 1992.<sup>1</sup>

	Adult female <i>n</i> = 5	Adult male <i>n</i> = 5	Juvenile female <i>n</i> = 12	Juvenile male <i>n</i> = 6	Adults <i>n</i> = 10	Juveniles <i>n</i> = 18	Females <i>n</i> = 17	Males <i>n</i> = 11
Annual	358.1 (243.9)	291.4 (183.5)	201.5 (192.2)	93.1 (118.4)	324.8 <sup>2</sup> (206.5)	165.4 (175.5)	247.6 (213.8)	183.2 (176.6)
Spring	39.0 (20.8)	111.0 (142.7)	140.0 (182.9)	575.0 (773.0)	75.0 (101.9)	284.8 (435.8)	89.5 (132.1)	265.5 (434.7)
Summer	110.7 (149.6)	90.0 (80.8)	63.1 (84.2)	6.8 (8.9)	102.1 (121.2)	46.5 (74.8)	80.6 (111.1)	48.4 (69.7)
Fall	242.3 (222.6)	136.4 (88.3)	94.6 (81.1)	41.4 (29.0)	194.2 (175.9)	75.0 (70.7)	143.8 (154.8)	81.0 (75.4)
Winter	91.8 (43.2)	168.8 (158.9)	152.8 (142.0)	334.7 (371.3)	126.0 (109.8)	213.4 (235.3)	125.1 (108.8)	239.9 (257.8)

<sup>1</sup>SD = standard deviation; *n* = sample size; Spring = March–May; Summer = June–August; Fall = September–November; Winter = December–February. The total number of fixes for annual home range analysis was 3788, with the mean number of fixes/fox being 129.3 (SD = 117.6)

<sup>2</sup>Adult ranges > juvenile ranges ( $P = 0.02$ ).

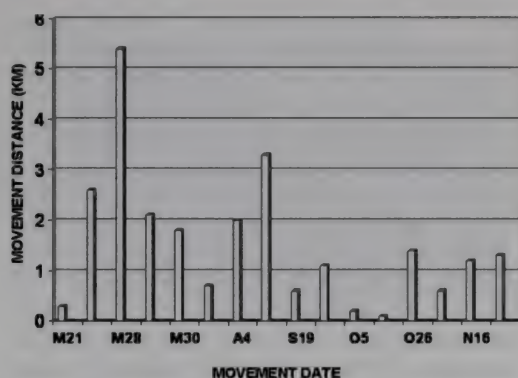


FIGURE 1. Nightly (1800 to 0600) movements (km) during March to December 1990 of an adult female Red Fox (that had a litter). M = March, A = April, S = September, O = October, N = November; monitoring nights included March 21, 22, 28, 29, and 30; April 3, 4, and 26; September 19; October 3, 5, 18, and 26; November 12 and 16; and December 13, 1990.

differences detected with respect to the dispersal distances traversed by foxes (juveniles and adults, 17.2 km and 21.8 km, respectively,  $P = 0.648$ ) (males and females, 20.2 km and 18.2 km, respectively,  $P = 0.847$ ). However, a significant negative correlation was detected between home range size and dispersal distance of foxes ( $y = 866.4 - 23.91x$ ;  $r = -0.70$ ;  $P = 0.0348$ ) (Figure 3). Thirty-six percent (4/11) of the foxes dispersed in December and 18% (2/11) dispersed in August. Dispersal of foxes also occurred in February, March, June, July, September, and November. The dispersing foxes consisted of 4 juvenile males, 3 adult females, 2 juvenile females, and 2 adult males. The bearing angles of the dispersing foxes varied from 10 to 300 degrees, and we could not detect a mean direction of dispersal, i.e., the circular distribution was uniform ( $\bar{z} = 1.23$ ,  $0.5 < P < 0.2$ ) (Figure 2).

**Habitat utilization:** Detailed habitat utilization analyses were not possible because fox locations were determined by triangulation; however, inferences on habitat use could be drawn where locations were in large tracts of habitat, such as ravines, woodlots, residential areas, and golf courses. Foxes generally remained within the greenbelt area (e.g., golf course, ravine system, forested park) where they had been captured until they dispersed. Dispersal occurred across many habitat types, including residential, commercial, industrial, and green areas. Foxes also crossed and/or travelled along major highways and city streets as well as railway lines and hydroelectric corridors to get to adjacent greenbelt areas. Half of the foxes (14 of 28 foxes for which we had sufficient data for home range analyses) used golf courses extensively but often traversed the ravine systems and visited residential areas. At least eight of the foxes used residential areas extensively,

based on triangulation calculations. Generally, fox use of greenbelt areas was extensive, with other habitat classes (e.g., residential) being used opportunistically.

**Mortality:** Eleven of the 33 radio-collared foxes were confirmed to have died during the study period. Nine foxes were listed as missing, collars were removed from 5, and 8 foxes still had functioning collars at the end of the study. Of the 11 known mortalities, the cause of death was known for 6 of those: 3 were killed by collisions with vehicles, 2 were killed by predators (Coyote, *Canis latrans*, and/or dog), and one was shot.

**Parturition/Litters:** During this study, fox kits were observed on 19 March 1990 at the Toronto Golf Course running and playing about the entrance of the maternity den. The kits appeared to be about three weeks of age, so breeding probably occurred during mid-January and parturition likely occurred in late February or early March. Another vixen, radio-collared as a juvenile in 1990, had six kits as a yearling. She was observed on 4 April 1991 with the kits, which appeared to be about six to eight weeks of age, so parturition must have occurred during late February and breeding in early to mid-January.

Five of the foxes were known to have litters during the study period (as evidenced by observations at the den site when the kits were one to two months of age). The number of kits observed at the den sites were 2, 2, 4, 5, and 6 (this does not confirm litter size). Of the five foxes with litters, three were juveniles when they were radio-collared. Two of those had litters when they were two years old and one when it was a yearling.

## Discussion

Red Fox social structure is based on a family unit. In Ontario, the family generally consists of an adult male and vixen and the kits; however, sometimes several related females may belong to the family unit (Voigt 1987). According to Voigt (1987), mating by Red Foxes in Ontario occurs during late January or early February. With an average gestation period of 51–53 days, foxes usually give birth in early March in rural areas of the province (Voigt 1987). In our Toronto study, we observed kits outside the maternity den during March and April, so breeding must have occurred in early to mid-January and parturition during late February to early March.

Litter sizes in rural Ontario were as high as 8.0, as reported by Voigt and Macdonald (1984), based on placenta scar counts. The greatest number of kits we observed in Toronto was six; however, prenatal mortality may have accounted for the difference between litter sizes in urban and rural foxes in Ontario. In rural Ontario, it is estimated that 80–90% of yearling vixens and 95% of older vixens produce litters (Voigt and Macdonald 1984). We also observed litters in yearling and two-year-old vixens in Toronto but did not have data on the proportion having litters. It is acknowledged that any differences in the percentage of foxes

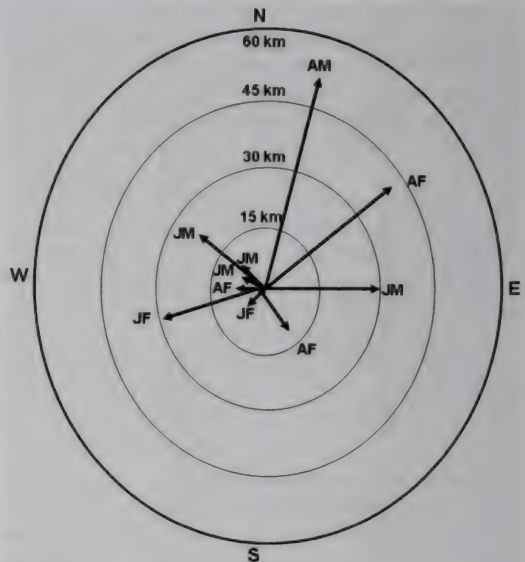


FIGURE 2. Dispersal direction and distance of Red Foxes in metropolitan Toronto, Ontario, during 1989–1992. AM = adult male; AF = adult female; JM = juvenile male; JF = juvenile female.

breeding, age at breeding, and litter sizes between foxes in urban and rural areas of Ontario is most likely related to food abundance, the density of foxes, and mortality rates (Voigt 1987).

Most mortality of foxes in rural Ontario habitats is the result of collisions with vehicles, trapping, shooting, and diseases such as rabies (Voigt 1987). Twenty-five percent of juvenile fox mortality during one telemetry study in rural Ontario was the result of road kills, with 60% from hunting and trapping (Voigt 1987). Similarly, in our study in urban Toronto, mortality was due to collisions with vehicles and predation, but shooting also accounted for one mortality. As our foxes were vaccinated against rabies, we could not evaluate mortality due to that disease; however, historically, it has been significant in Toronto, as noted in Rosatte et al. (2007).

Red Foxes exist in Ontario by consuming a variety of prey, including species of lagomorphs, birds, mice, and voles. In rural Ontario, as much as 50% of the diet of foxes may be Meadow Voles (*Microtus pennsylvanicus*) (Voigt 1987). Although we did not obtain any quantitative food habit data in our study in Toronto, we did observe foxes preying on small rodents, Woodchucks (*Marmota monax*), and domestic cats, as well as scavenging on garbage. In addition, remains of a variety of animals were found around the kit-rearing dens, including various bird species, rabbits (Leporidae), Raccoons (*Procyon lotor*), and squirrels (*Sciurus* sp.). An omnivorous foraging strategy obviously contributes to the success of foxes living in urban environments such as metropolitan Toronto.



Home range and movement by Red Foxes is habitat dependent. In urban areas of Great Britain, where fox use of residential areas was extensive, ranges as small as 10 ha were noted (Harris 1977; Voigt and Macdonald 1984). In one Toronto study, Adkins and Stott (1998) reported mean ranges of 52 ha for Red Foxes. However, that study involved tracking foxes for only a few months. We found that when foxes in Toronto were tracked for at least a year, home ranges were significantly larger than those reported by Adkins and Stott (1998). However, our seasonal ranges (fall) for some foxes were comparable to those of Adkins and Stott (1988).

In rural habitats of southern Ontario, home range of foxes averaged 900 ha and ranged between 500 and 2000 ha (Voigt and Tinline 1980). In our study in Toronto, adult and juvenile annual ranges averaged 325 ha and 165 ha, respectively, with nightly movements averaging 3.5 km during June to November. These figures are smaller than ranges for rural Ontario foxes but larger than the ranges reported for urban foxes in Great Britain (Voigt and Macdonald 1984). This may be related to the fact that foxes in Great Britain make extensive use of residential areas and there is little green space (Harris 1977; Harris and Rayner 1986), whereas urban foxes in Ontario live in urban environments but make use of greenbelts and ravine areas as well as golf courses which accommodate greater movement by foxes. In addition, foxes in Toronto move from one "green" patch to another by traversing residential and commercial areas. They use railway lines, ravine systems, and hydroelectric corridors for movement in metropolitan Toronto.

We also detected a negative correlation between fox home range size and dispersal distance. This is in contrast to other studies (Trehwella et al. 1988) where the larger the home range, the greater the dispersal distance. We have no explanation for this difference but the size and shape of ravine systems may have accommodated significant dispersals by Toronto foxes even though they had small home ranges. However, the ravine systems of Toronto are oriented in a north/south direction. One would expect that if ravine systems were used for dispersal, there would be a northward bias in dispersal, but we could not detect any directional bias in dispersal by Toronto foxes.

Foxes are fairly sedentary during the breeding and parturition periods in the late winter and spring. Family life normally focuses on the kit-rearing den until kits are old enough to venture away from the den on their own during the summer. As kits become independent, movements increase. Foxes in our study were fairly active during the evenings, with movements averaging 3.5 km (SD 2.9). Adkins and Stott (1998) also reported that foxes were active during the evenings in Toronto, with mean movements of 3.4 to 8.6 km. Most male kits and some female kits disperse from the parental range before they are one year of age (Voigt 1987).

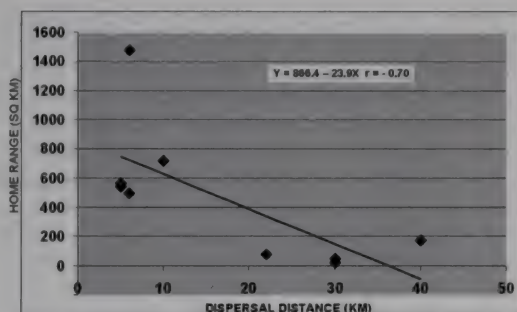


FIGURE 3. Negative correlation between dispersal distance and home range size of Red Foxes in metropolitan Toronto, Ontario.

Peak dispersal by foxes in rural southern Ontario habitats occurred during October and November but ranged from August to March (Voigt 1987). In our urban Toronto study, peak dispersal was in December but occurred in other months as well. This was expected as juvenile foxes leave their natal range.

Most male fox dispersals in rural Ontario were about 30 km but one fox traversed 122 km (Voigt 1987). Female dispersal was about 8 km and ranged from 1 to 50 km (Voigt 1987). During a rabies control program in Scarborough, Ontario (a suburb of metro Toronto), an adult female Red Fox was captured, ear-tagged, and released in 1994. That fox was captured 170 km to the east in 1996 (Rosatte 2002). In our Toronto study, dispersal averaged 19 km but we could detect no age or sex differences with respect to dispersal.

This is significantly greater than the dispersal distances reported by Harris and Trehwella (1988) for Bristol (mean in the 1 to 3 km range for juvenile foxes) as well as those reported by Robinson and Marks (2001) for foxes in Melbourne, Australia (3.5 km and 2.0 km for male and female foxes, respectively). This was no doubt due to habitat differences between Bristol and Toronto, in that foxes use high-density housing areas in Bristol (i.e., there is little green space available) while foxes in Toronto make extensive use of ravine systems and greenbelt areas, which may be long and narrow, making effective movement corridors.

Data acquired from this study were used to design an oral rabies vaccination tactic for metropolitan Toronto. Knowledge of the areas frequented by foxes as well as their potential movement assisted researchers in determining where vaccine baits should be placed, both by ground distribution and from fixed-wing aircraft and helicopters, and how widely spaced the baits should be. Between 1989 and 1991, about 55% to 80% of the foxes sampled had contacted rabies vaccine baits that had been distributed along the ravine systems of metropolitan Toronto (Rosatte et al. 1992, 2007). In fact, the program was so successful that rabies was eliminated from foxes in metropolitan Toronto in 1996 (Rosatte et al. 2007).

During the late 1980s and early 1990s, Red Foxes were doing extremely well in metropolitan Toronto. At that time, it is estimated that there were in excess of 1000 foxes in that urban complex (about 1 fox/km<sup>2</sup>) (Rosatte unpublished data; Rosatte et al. 1991). Their success appeared to be a function of high reproductive potential, including large litter size and breeding by yearling vixens, and omnivorous food habits, as well as their dispersal potential and ability to survive in the presence of predators such as dogs and Coyotes as well as automobiles. The data from this study were used to design a rabies control tactic for metropolitan Toronto that proved to be very effective. However, as rabies has been controlled in Toronto, it remains to be seen whether other diseases and parasites, such as distemper, parvovirus, and mange, will play a greater role in limiting fox populations in that urban complex. However, one thing is certain—due to the dispersal capability of Toronto foxes (up to 48 km), they are capable of spreading infectious diseases and parasites significant distances, including from urban to rural habitats.

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# Red Maple, *Acer rubrum*, Wetland Composition and Structure in Nova Scotia

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Red Maple (*Acer rubrum*) wetlands occur when Red Maple dominated forest occupies imperfectly drained to saturated soils. Plots were established in 28 Red Maple wetlands in Nova Scotia to document structure and plant composition. Non-metric multidimensional scaling (NMDS) was used to assess vegetation differences by wetland type (floodplain, depression, slope) and geographic region (inland vs. coastal and western vs. eastern shore). Seventy-eight species of vascular plants and 35 species of non-vascular plants were found in plots. Two species of rare vascular plants and four rare *Sphagnum* species were found in plots or within the wetlands. *Sphagnum* species richness was very high. Red Maple wetlands are structurally complex, often having five distinct vertical layers. NMDS species composition analyses suggest little difference between wetland types and geographic regions. Given the diversity of vascular and non-vascular plants and the structural complexity of Red Maple wetlands in Nova Scotia, these wetlands make a significant contribution to the biodiversity and heterogeneity of the landscape.

**Key Words:** Red Maple, *Acer rubrum*, *Sphagnum*, wetland, composition, structure, Nova Scotia.

Red Maple (*Acer rubrum*) is a common forest species of Nova Scotia occurring in a variety of ecological conditions (Saunders 1995). In imperfectly drained to saturated soils, Red Maple dominated forest forms Red Maple swamps or wetlands. These wetlands can occur as depressions, side slope seeps, or seasonally flooded areas such as river floodplains. Soils can be mineral or organic with seasonal, intermittent, or continuous flooding (Rheinhardt 2007).

Red Maple wetlands are often a unique community of flora not found elsewhere in the landscape and they contribute to the diversity of the surrounding landscape. Red Maple wetlands also provide the benefits associated with other wetlands, such as flood control, water storage, water quality protection, and habitat for wildlife (Golet et al. 1993).

Rare species have also been associated with Red Maple wetlands in Nova Scotia. Southern Twayblade (*Listera australis*), a rare species in Nova Scotia, is associated with these types of wetlands (Zinck 1998). Maass (1986), Cameron and Neily (2008), and Cameron and Richardson (2006) have reported a community of rare lichens in Red Maple and other forested wetlands in Nova Scotia. The lichen community includes the globally endangered Boreal Felt Lichen (*Erioderma pedicellatum*).

There have been several published works on Red Maple wetlands in the northeastern United States (Ehrenfeld and Gulick 1981; Golet et al. 1993; Rheinhardt 2007). However, there are no published detailed studies of Red Maple wetlands in Nova Scotia. Plots were established in 28 Red Maple wetlands in Nova Scotia to document the structure and plant composition.

## Methods

Plots were established in Red Maple wetlands as part of a larger project to assess the biodiversity of protected wilderness areas and candidate protected areas (Figure 1) (Table 1). Provincial wilderness areas make an ideal network for study because they were designed to represent the variety of ecosystems present in the province and they are relatively undisturbed by human impacts. Wilderness areas are legally protected from development, including forestry, mining, and road building.

Transects were established in 10 protected wilderness areas and 5 candidate wilderness areas. Transects were designed to traverse the variety of topographical features of each landscape. Whenever a Red Maple wetland was encountered, a plot was established. An area was considered a Red Maple wetland if it met the following criteria: (1) there were Red Maples in the canopy layer; (2) the area had imperfectly drained soil, poorly drained soil, or saturated soil; and (3) it had facultative or obligate wetland plant species. Twenty-four Red Maple wetland plots were established from the transects and an additional four plots were established because they were habitat of known rare species. Once encountered, each Red Maple wetland was traversed to determine the extent and variation of plants occurring there. A representative area was subjectively selected for a 20 m × 20 m plot. Presence and abundance of plant species and environmental site factors were collected at each plot, following standards set out by the Ecological Society of America (Jennings et al. 2002).

TABLE 1. North longitude and west latitude, wetland type, geographic position, and region of study plots.

Plot Number	Latitude	Longitude	Wetland type	Position	Region
1	44.070918	-65.549466	Floodplain	Inland	West
2	44.275538	-65.050733	Floodplain	Inland	West
3	44.276337	-65.298548	Floodplain	Inland	West
4	44.074093	-65.563302	Floodplain	Inland	West
5	44.072277	-65.563149	Depression	Inland	West
6	44.069989	-65.562813	Depression	Inland	West
7	44.074083	-65.560130	Depression	Inland	West
8	44.077982	-65.575297	Depression	Inland	West
9	44.073346	-65.561659	Depression	Inland	West
10	44.279205	-65.072039	Depression	Inland	West
11	44.446621	-64.820082	Depression	Inland	West
12	44.439111	-64.821268	Depression	Inland	West
13	44.437143	-64.823896	Depression	Inland	West
14	44.074083	-65.560130	Depression	Inland	West
15	44.914877	-63.059061	Depression	Coast	East
16	43.839248	-65.193824	Depression	Coast	West
17	43.836494	-65.198001	Depression	Coast	West
18	44.449973	-64.817044	Depression	Inland	West
19	44.448001	-64.818755	Depression	Inland	West
20	44.911978	-63.073881	Depression	Coast	East
21	44.863145	-63.023263	Depression	Coast	East
22	44.863271	-63.024149	Depression	Coast	East
23	44.870089	-63.090449	Depression	Coast	East
24	44.836204	-63.064700	Side-slope	Coast	East
25	44.840165	-63.064540	Side-slope	Coast	East
26	44.932328	-63.047116	Side-slope	Coast	East
27	43.855017	-65.021355	Side-slope	Coast	West
28	43.849514	-65.190480	Side-slope	Coast	West

Cover abundance classes for each plant species by layer was recorded within each plot. Seven cover classes were used based on the percentage of ground covered by each species within the 20 m × 20 m plot: 1 = trace, 2 = 0–1%, 3 = 2–5%, 4 = 6–25%, 5 = 26–50%, 6 = 51–75%, 7 = 76–100%. The five layers in which plant cover classes were estimated were (1) canopy, (2) subcanopy, (3) shrub, (4) herb, and (5) moss/lichen. Vascular plants were identified using Zinck (1998), mosses were identified using Ireland (1982), and lichens were identified using Brodo et al. (2001). Voucher specimens are held by Nova Scotia Environment.

Aspect was recorded at each plot as the direction in degrees from North that the ground was facing. Slope of the ground on which the plot occurred was estimated in percent. Universal Transverse Mercator coordinates and elevation were recorded using a handheld global positioning system (GPS). Elevation was later compared to 1:50 000 scale topographic maps to ensure accuracy. Soil drainage for each plot was recorded as one of three classes:

(1) *Imperfectly drained* – Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic plants.

(2) *Poorly drained* – Water is removed so slowly that

the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic plants cannot grow.

(3) *Saturated* – Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season.

Each plot was described as occurring in a depression, slope, or floodplain. In order to get an understanding of geographic differences that might occur in Red Maple wetlands, plots were classified as coastal (within 20 km of the coast) or inland (greater than 20 km from the coast) and by geographic region. All plots within Kings, Annapolis, Digby, Yarmouth, Shelburne, Queens or Lunenburg counties were classified as western. Eastern shore was assigned to plots in Halifax or Guysborough counties, and plots in all other counties were considered northern.

## Analysis

Non-metric multidimensional scaling (NMDS) was used to assess differences between Red Maple wetland plots by type of wetland (depression, slope, floodplain) and geographic distribution (coastal vs. inland and western vs. eastern shore). NMDS plots were done separately for each layer. Shrub and subcanopy were



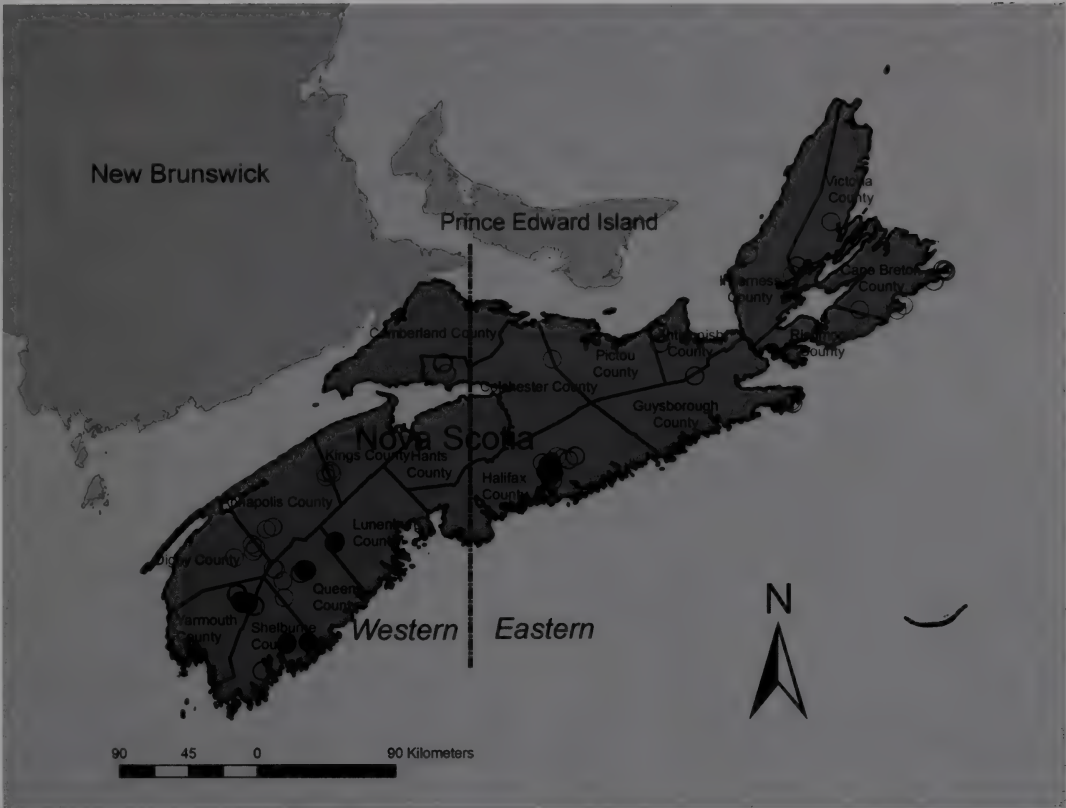


FIGURE 1. Locations of study plots containing Red Maple wetlands (black dots) and survey areas where Red Maple wetlands were not found (circles).

not assessed because of the low abundance of species in these layers. NMDS is part of a family of multivariate ordination methods used to arrange communities along environmental gradients based on community composition (ter Braak 1987). Differences (or similarities) between communities are calculated and then plotted in such a way that the distances between sites are maximally correlated with ecological distances. NMDS is one of the most robust methods of multivariate analysis (McCune et al. 1997; McCune et al. 1998; Neitlich et al. 2003). Barbour et al. (1999) compared four ordination techniques using tree species composition with *a priori* known differences. They found NMDS and canonical correspondence analysis the most useful methods in discerning differences in community type. To determine number of dimensions for NMDS analyses, five runs were done for each layer using 1 to 5 dimensions. Scree plots were created by plotting dimensions against stress. The number of dimensions was determined at the point where stress levelled off. Shepard diagrams were also created for each run by plotting reduced distances against the observations input data.

Results

No Red Maple wetlands were encountered in transects in the eight protected areas and three candidate protected areas in northern Nova Scotia. Transects in the four protected areas and one candidate protected area in western Nova Scotia resulted in 20 Red Maple wetland plots. Transects in the two protected areas and two candidate protected areas in the eastern shore resulted in 8 Red Maple wetland plots.

Four plots occurred in floodplains, 19 in depressions, and 5 on slopes. Sixteen plots were classified as inland and 12 were classified as coastal. Soil drainage ranged from saturated to imperfect, with most sites being poorly drained.

Seventy-eight species of vascular plants and 35 species of non-vascular plants were found in plots (Table 2). Two rare species of vascular plants were found within the wetlands but outside plots. Southern Twayblade is considered S1 (Extremely rare—may be especially vulnerable to extirpation, typically 5 or fewer occurrences or very few remaining individuals) by the Atlantic Canada Conservation Data Centre (ACCDC) and yellow (sensitive) by the Province of Nova Scotia.

TABLE 2. Mean cover class of plants in 28 plots in Red Maple wetlands in Nova Scotia by layer, wetland type, and geographic distribution and for all plots and total number of plots of the 28 each species occurred in. Cover classes: 1 = Trace, 2 = 0–1%, 3 = 1–5%, 4 = 6–25%, 5 = 26–50%, 6 = 51–75%, 7 = 76–100%.

Species	Wetland type			Position		Region		Mean	
	Floodplain n = 4	Depression n = 19	Slope n = 5	Inland n = 16	Coast n = 12	Western n = 20	Eastern n = 8	cover n = 28	Occurrence n = 28
<b>Canopy</b>									
<i>Abies balsamea</i>	2	3	3	3	3	3	3	3	10
<i>Acer rubrum</i>	6	4	3	5	3	4	3	4	28
<i>Betula papyrifera</i>	0	2	0	2	2	2	2	2	5
<i>Fraxinus americana</i>	0	4	2	4	2	4	2	3	2
<i>Larix laricina</i>	0	2	0	2	3	3	2	2	8
<i>Picea mariana</i>	2	3	4	3	4	3	4	3	16
<i>Picea rubens</i>	3	5	2	3	4	4	3	4	6
<i>Pinus strobus</i>	0	2	0	4	0	4	0	2	2
<i>Populus tremuloides</i>	0	5	0	0	5	5	0	5	1
<i>Quercus rubra</i>	0	5	2	0	4	4	0	4	2
<i>Tsuga canadensis</i>	4	0	0	4	0	4	0	4	1
<b>Subcanopy</b>									
<i>Abies balsamea</i>	3	4	3	3	3	3	4	3	8
<i>Acer rubrum</i>	0	2	0	0	2	1	3	2	4
<i>Alnus incana</i>	0	3	0	0	3	0	3	3	1
<i>Betula papyrifera</i>	0	2	0	0	2	1	2	2	2
<i>Betula populifolia</i>	0	1	0	1	0	1	0	1	1
<i>Larix laricina</i>	0	2	0	0	2	0	2	2	1
<i>Nemopanthus mucronata</i>	0	4	0	0	4	0	4	4	1
<i>Picea mariana</i>	0	4	4	2	4	2	4	4	6
<i>Picea rubens</i>	4	0	0	4	0	4	0	4	1
<i>Pinus strobus</i>	0	1	0	1	0	1	0	1	1
<i>Quercus rubra</i>	0	1	0	1	0	1	0	1	1
<i>Sorbus americana</i>	0	3	0	2	3	2	3	3	2
<i>Tsuga canadensis</i>	4	0	0	4	0	4	0	4	1
<b>Shrub Layer</b>									
<i>Abies balsamea</i>	3	3	2	3	3	2	3	3	9
<i>Acer rubrum</i>	0	3	2	3	2	2	3	2	8
<i>Alnus incana</i>	0	4	0	4	4	4	3	4	5
<i>Amelanchier</i> spp.	0	1	0	1	2	1	2	1	3
<i>Aronia melanocarpa</i>	1	3	0	1	3	3	1	2	3
<i>Chamaedaphne calyculata</i>	1	0	0	1	0	1	0	1	1
<i>Fraxinus americana</i>	0	3	0	0	3	3	0	3	1
<i>Gaylussacia baccata</i>	2	3	5	3	4	3	4	4	7
<i>Ilex glabra</i>	3	3	0	3	0	3	0	3	2
<i>Ilex verticillata</i>	1	3	0	2	3	2	3	2	5
<i>Kalmia angustifolia</i>	3	3	4	3	3	3	3	3	10
<i>Kalmia polifolia</i>	0	3	0	0	3	3	0	3	1
<i>Larix laricina</i>	0	3	0	0	3	0	3	3	1
<i>Ledum groenlandicum</i>	1	3	4	1	3	2	3	3	10
<i>Myrica gale</i>	0	4	0	4	0	4	0	4	1
<i>Myrica pensylvanica</i>	0	2	2	0	2	2	0	2	2
<i>Nemopanthus mucronata</i>	2	3	3	2	3	2	4	3	12
<i>Picea rubens</i>	2	0	0	2	0	2	0	2	1
<i>Picea mariana</i>	0	3	3	3	3	3	3	3	12
<i>Rhododendron canadense</i>	0	3	0	3	3	3	0	3	2
<i>Rubus hispidus</i>	2	3	0	3	0	3	0	3	4
<i>Vaccinium angustifolium</i>	2	2	0	2	3	2	0	2	5
<i>Viburnum nudum</i>	1	3	0	2	3	2	3	2	13



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Species	Wetland type			Position		Region		Mean	
	Floodplain n = 4	Depression n = 19	Slope n = 5	Inland n = 16	Coast n = 12	Western n = 20	Eastern n = 8	cover n = 28	Occurrence n = 28
Herb Layer									
<i>Abies balsamea</i>	2	3	2	2	3	3	3	3	4
<i>Acer pensylvanicum</i>	2	0	0	2	0	2	0	2	1
<i>Acer rubrum</i>	0	2	2	4	2	2	2	2	11
<i>Amelanchier</i> spp.	0	1	0	0	1	0	1	1	1
<i>Aralia nudicaulis</i>	4	3	2	4	2	3	3	3	9
<i>Aster acuminatus</i>	3	3	0	3	3	3	2	3	9
<i>Aster</i> spp.	0	2	1	0	2	2	1	2	2
<i>Betula papyrifera</i>	1	2	0	1	2	2	0	2	2
<i>Carex intumescens</i>	0	4	0	4	0	4	0	4	1
<i>Carex</i> spp.	3	5	2	4	4	4	0	4	9
<i>Clintonia borealis</i>	2	0	2	2	2	2	2	2	3
<i>Coptis trifolia</i>	2	2	2	3	2	2	2	2	14
<i>Cornus canadensis</i>	3	3	3	3	3	3	3	3	21
<i>Cypripedium acaule</i>	0	2	2	2	2	2	0	2	2
<i>Dennstaedtia punctilobula</i>	0	2	4	0	3	4	3	3	3
<i>Diervilla lonicera</i>	0	1	0	0	1	0	1	1	1
<i>Dryopteris cristata</i>	0	1	0	1	2	1	0	1	3
<i>Epigaea repens</i>	2	2	3	2	3	2	3	2	3
<i>Fagus grandifolia</i>	2	0	0	2	0	2	0	2	1
<i>Gaultheria hispida</i>	3	3	2	3	2	3	2	2	10
<i>Gaultheria procumbens</i>	0	3	0	3	2	3	2	3	3
<i>Gymnocarpium dryopteris</i>	0	0	1	0	1	0	1	1	1
<i>Hamamelis virginiana</i>	1	0	0	1	0	1	0	1	1
<i>Impatiens capensis</i>	0	0	1	0	1	0	1	1	1
<i>Iris versicolor</i>	1	2	0	1	2	2	0	2	6
<i>Kalmia angustifolia</i>	0	3	2	0	3	3	3	3	7
<i>Ledum groenlandicum</i>	0	2	0	2	2	2	2	2	3
<i>Linnaea borealis</i>	0	3	3	2	4	2	4	3	5
<i>Lonicera canadensis</i>	0	2	0	0	2	0	2	2	1
<i>Lycopodium obscurum</i>	0	0	2	0	2	2	0	2	1
<i>Lycopus americanus</i>	0	0	2	0	2	0	2	2	1
<i>Maianthemum canadense</i>	2	2	1	2	2	2	2	2	10
<i>Medeola virginiana</i>	1	0	0	1	0	1	0	1	1
<i>Mitchella repens</i>	2	2	0	2	2	2	2	2	5
<i>Monotropa hypopithys</i>	0	0	1	0	1	0	1	1	1
<i>Myrica gale</i>	0	2	0	0	2	2	0	2	1
<i>Nemopanthus mucronata</i>	0	2	0	0	2	2	0	2	1
<i>Onoclea sensibilis</i>	0	0	2	0	2	0	2	2	1
<i>Osmunda cinnamomea</i>	2	5	4	4	4	4	5	4	22
<i>Osmunda regalis</i>	0	3	5	3	4	3	5	4	3
<i>Oxalis acetosella</i>	0	2	2	0	2	0	2	2	3
<i>Phegopteris connectilis</i>	0	4	0	4	0	4	0	4	2
<i>Picea mariana</i>	0	3	0	0	3	3	3	3	3
<i>Picea rubens</i>	3	0	0	3	0	3	0	3	1
<i>Pinus strobus</i>	2	2	0	2	2	2	0	2	2
<i>Pteridium aquilinum</i>	4	2	4	4	2	3	2	3	5
<i>Pyrola</i> spp.	1	0	2	1	2	1	2	2	2
<i>Pyrola secunda</i>	0	3	0	0	3	0	3	3	1
<i>Quercus rubra</i>	2	0	0	2	0	2	0	2	1
<i>Rhododendron canadense</i>	0	1	0	1	0	1	0	1	1
<i>Rosa nitida</i>	0	1	1	0	1	1	1	1	2
<i>Rosa</i> spp.	0	2	0	2	1	2	0	2	4
<i>Rubus pubescens</i>	0	3	3	4	2	3	2	3	10

TABLE 2. Mean cover class of plants in 28 plots in Red Maple wetlands in Nova Scotia by layer, wetland type, and geographic distribution and for all plots and total number of plots of the 28 each species occurred in. Cover classes: 1 = Trace, 2 = 0–1%, 3 = 1–5%, 4 = 6–25%, 5 = 26–50%, 6 = 51–75%, 7 = 76–100%.

Species	Wetland type			Position		Region		Mean cover n = 28	Occurrence n = 28
	Floodplain n = 4	Depression n = 19	Slope n = 5	Inland n = 16	Coast n = 12	Western n = 20	Eastern n = 8		
<i>Sarracenia purpurea</i>	0	3	1	3	1	3	1	2	2
<i>Scutellaria lateriflora</i>	0	2	0	2	0	2	0	2	1
<i>Smilacina trifolia</i>	0	5	4	5	4	5	4	5	2
<i>Spiraea alba</i>	0	1	3	2	2	1	3	2	4
<i>Taxus canadensis</i>	0	2	2	0	2	0	2	2	3
<i>Thalictrum pubescens</i>	0	3	0	0	3	3	0	3	1
<i>Thelypteris palustris</i>	0	2	2	2	2	1	2	2	5
<i>Thelypteris simulata</i>	1	4	0	3	0	3	0	3	2
<i>Toxicodendron rydbergii</i>	1	2	3	2	2	2	0	2	6
<i>Trientalis borealis</i>	4	2	1	2	2	2	2	2	13
<i>Vaccinium angustifolium</i>	0	2	2	3	2	2	3	2	6
<i>Vaccinium myrtilloides</i>	0	2	0	0	2	0	2	2	1
<i>Vaccinium vitis-idaea</i>	0	2	0	0	2	0	2	2	1
<i>Viburnum nudum</i>	0	2	1	1	2	2	0	2	4
<i>Viola</i> spp.	0	3	1	3	1	3	1	2	3
<b>Moss/Lichen Layer</b>									
<i>Atricum</i> spp.	0	0	1	0	1	0	1	1	1
<i>Aulacomnium palustre</i>	0	1	0	0	1	0	1	1	1
<i>Bazzania trilobata</i>	4	2	3	3	3	2	3	3	12
<i>Cladonia maxima</i>	0	1	0	0	1	0	1	2	1
<i>Cladonia mitis</i>	0	0	2	0	2	2	0	1	3
<i>Cladonia rangiferina</i>	0	1	1	0	1	0	1	2	4
<i>Cladonia terrae-novae</i>	0	2	0	2	1	2	1	1	2
<i>Dicranum majus</i>	0	2	1	2	1	2	0	2	2
<i>Dicranum polysetum</i>	3	0	0	3	0	3	0	3	1
<i>Dicranum scoparium</i>	2	1	2	2	2	2	2	2	5
<i>Dicranum undulatum</i>	0	2	0	0	2	0	2	2	1
<i>Dicranum</i> spp.	2	0	0	2	0	2	0	2	2
<i>Hylocomium splendens</i>	0	3	2	0	3	2	3	3	10
<i>Hypnum</i> sp.	2	0	2	2	2	2	0	2	3
<i>Leucobryum glaucum</i>	2	0	2	2	2	2	2	2	2
<i>Pleurozium shreberi</i>	3	3	3	3	3	3	3	3	14
<i>Polytrichum commune</i>	0	1	0	0	1	0	1	1	1
<i>Polytrichum juniperinum</i>	0	1	0	0	1	0	1	1	1
<i>Polytrichum strictum</i>	0	2	0	2	0	2	0	2	1
<i>Polytrichum</i> spp.	3	1	0	3	1	2	0	2	2
<i>Ptilium crista-castrensis</i>	0	2	0	0	2	0	2	2	1
<i>Rhizomnium punctatum</i>	6	0	0	6	0	6	0	6	1
<i>Rhytidiadelphus triquetrus</i>	0	0	2	0	2	0	2	2	1
<i>Sphagnum austinii</i>	0	4	0	4	0	4	0	4	1
<i>Sphagnum capillifolium</i>	0	4	3	3	3	3	4	3	10
<i>Sphagnum centrale</i>	0	4	4	0	4	0	4	4	2
<i>Sphagnum cuspidatum</i>	0	3	0	0	3	3	0	3	1
<i>Sphagnum flavicomens</i>	0	5	0	5	0	5	0	5	1
<i>Sphagnum fuscum</i>	0	0	3	0	3	0	3	3	1
<i>Sphagnum girgensohnii</i>	3	5	5	4	5	4	4	4	14
<i>Sphagnum magellanicum</i>	5	3	5	3	4	3	4	4	8
<i>Sphagnum papillosum</i>	0	0	3	0	3	3	0	3	1
<i>Sphagnum russowii</i>	0	2	0	2	0	2	0	2	1
<i>Sphagnum squarrosum</i>	4	5	0	5	1	5	0	5	8
<i>Sphagnum wulfianum</i>	3	2	0	3	1	3	1	2	4
<i>Sphagnum</i> spp.	0	6	0	6	0	6	0	6	3



Dwarf Chain Fern is ranked S2 (Rare—may be vulnerable to extirpation due to rarity or other factors, 6 to 20 occurrences or few remaining individuals) by the ACCDC and yellow by the Province of Nova Scotia.

*Sphagnum* species richness was high, with 12 species found, including 3 rare species. *Sphagnum centrale* was found in two plots and *S. flavicomens* was found in one plot. Both species are ranked S2 (Rare) in Nova Scotia by the ACCDC and G3 (Uncommon—found only in a restricted range, even if abundant at some locations, 21 to 100 occurrences) globally by Nature Serve. *Sphagnum wulfianum* was found in four plots and is considered S1 (Extremely rare) by ACCDC. *Sphagnum torreyanum* was found outside the plot in the river adjacent to the Red Maple floodplain wetland on the Shelburne River. *Sphagnum torreyanum* is ranked S2 (Rare) in Nova Scotia by the ACCDC. *Sphagnum* species have not yet been ranked by the Province of Nova Scotia.

Eleven tree species were found in the canopy. Red Maple was found in all plots in varying amounts. Black Spruce (*Picea mariana*) was the next most common species, found in 16 of 28 plots, followed by Balsam Fir (*Abies balsamea*) in 10 of 28 plots. Ten plots had a subcanopy present, most often with Balsam Fir (8 of 28 plots) or Black Spruce (6 of 28 plots). Red Maple occurred in the subcanopy in 4 of 28 plots.

Mountain Holly (*Nemopanthus mucronata*) was the most commonly occurring shrub (12 of 28 plots) in the shrub layer. Labrador Tea (*Ledum groenlandicum*) and Lambkill (*Kalmia angustifolia*) were the next most common, occurring in 10 of 28 plots. Red Maple, Balsam Fir, and Black Spruce were common occurrences in the shrub layer, found in 8, 9, and 12 of 28 plots, respectively.

Cinnamon Fern (*Osmunda cinnamomea*) and Bunchberry (*Cornus canadensis*) were the most commonly occurring herbs, with 22 and 21 occurrences in 28 plots, respectively. Other common herbs include Gold Thread (*Coptis trifolia*), Starflower (*Trientalis borealis*), Dewberry (*Rubus pubescens*), and False Lily of the Valley (*Maianthemum canadense*). The most common tree species found in the herb layer include Red Maple, Balsam Fir, and Black Spruce.

*Sphagnum* species dominated the moss/lichen layer and occurred in every plot. The most commonly found species were *S. girgensohnii*, found in 14 plots, and *S. capillifolium*, found in 10 plots. *Bazzania trilobata* was a common liverwort (found in 12 plots) and Shrebbers' Moss (*Pleurozium shreberi*) was the most common moss (found in 14 plots).

NMDS suggested little differences between wetland types or region. Scree plots for the herb and bryophyte layers show no levelling off at five dimensions for NMDS, indicating more variables are needed to explain differences between plots. Scree plot for canopy species, however, indicates stress is minimized with two dimensions. There is little clustering in the NMDS

plot for canopy species, indicating small differences between wetland type and region. There were, however, some observable differences between wetland type and region in the canopy layer. There were more plots with Balsam Fir in western Nova Scotia and more Eastern Larch (*Larix laricina*) in plots in the eastern shore. Coastal plots had greater occurrences of Balsam Fir than inland plots. Floodplains tended to have a higher canopy cover of Red Maple than depressions or slopes, while depressions had a greater frequency of Black Spruce. Slope wetlands had only one plot with Black Spruce.

There are some observable differences between wetland types and regions in the herb and moss/lichen layer. Lambkill was found only in plots in the eastern shore, while Creeping Snowberry (*Gaultheria hispida*) and Iris (*Iris versicolor*) occurred more frequently there than in western Nova Scotia. Cinnamon Fern occurred more often in plots in western Nova Scotia. The eastern shore tended to have greater richness and abundance of bryophytes. Coastal plots had more occurrences of Eastern Teaberry (*Gaultheria procumbens*) and Lambkill in the herb layer and *Bazzania trilobata* and *Sphagnum capillifolium* in the moss/lichen layer. Step Moss (*Hylocomium splendens*) was found only in coastal plots, and *Sphagnum squarrosum* was found only in inland plots. Floodplains had no occurrences of Lambkill, Dewberry (*Rubus pubescens*) or White Meadowsweet (*Spiraea alba*), and depressions were the only wetland type with Labrador Tea in the herb layer. Floodplains were the only wetland type without *Sphagnum capillifolium* and had the lowest *Sphagnum* species richness.

## Discussion

Regional distribution of plots may reflect the geographic distribution of Red Maple wetlands within the province. The transects were not designed to measure the distribution of Red Maple wetlands in the province and likely do not provide a representative sample. However, no Red Maple wetlands were encountered in transects in northern Nova Scotia. The low density in northern Nova Scotia (compared to western Nova Scotia and the eastern shore) may be a reflection of topography. Northern Nova Scotia has more highland terrain, with many more steep slopes and valleys (Davis and Browne 1996) that provide fewer topographic opportunities for wetlands to be established. It is unlikely that Red Maple wetlands do not occur in northern Nova Scotia, but density may be much lower than elsewhere in the province.

There were fewer differences in plant species composition by wetland type than expected. The availability of water is a significant determining factor in the occurrence of plant species and in the composition of plant communities (Barbour et al. 1999). Hydrological setting, e.g., depression, explains timing, duration, and frequency of soil saturation and thus would be expected

to influence the composition of plant species. Rheinhardt (2007) found differences in plant species composition between Red Maple wetland types in his study sites in Massachusetts. Plots in this study were assigned a wetland type based on field observations. It is possible that different hydrological dynamics were occurring than were observed in the field. Further, differences in plant species composition in wetlands in Massachusetts and Nova Scotia may help explain response. For example, Eastern White Cedar (*Thuja occidentalis*), a species strongly influenced by soil moisture (Farrar 1995), was not found in Nova Scotia study sites.

Greater regional differences in Red Maple wetlands might be expected given differences in geology, soils, and climate between plots. For example, Dzikowski (1985) identified the Atlantic coast of Nova Scotia as a distinct climate region separate from the interior of the province. Ecological land classification systems, which incorporate topography, soils, and geology, also identify distinct regions between areas of study plots (Lynds and LeDuc 1995; Davis and Browne 1996). However, the Red Maple community may be responding more to microclimate and microtopography than large-scale landscape features. There may also be some other attribute that Red Maple wetland communities are responding to. More research is needed to determine what factors affect the composition of Red Maple wetland communities.

Homogeneity of the Red Maple community in Nova Scotia suggests a repeating discrete assemblage of species with only small changes between wetland type and region of the province. This supports the concept of plant associations and confirms that they can be recognized and defined in the field.

Red Maple wetlands in Nova Scotia are structurally complex. Thirty-six percent of plots had a subcanopy and 93% had a shrub layer. Tree species were frequently found in the herb, shrub, and subcanopy layers, suggesting Red Maple wetlands will regenerate themselves if left undisturbed.

The relative dominance of Red Maple in these wetlands varies and may change over time. The cover of Red Maple in the canopy varied greatly between plots, with Balsam Fir and Black Spruce often within higher cover classes. This variation was also reflected in the other layers. Some plots have high cover of Red Maple in the canopy but little in other layers, suggesting other species may later become dominant if no major disturbance occurs.

Red Maple wetlands can provide habitat for some rare vascular plants. Southern Twayblade and Dwarf Chain Fern, Extremely rare and Rare, respectively, in Nova Scotia, were each found in a single wetland in western Nova Scotia. In a summary of research on Red Maple wetlands in the northeastern U.S., Golet et al. (1993) found that 33% of plant species known to occur in Red Maple swamps are considered rare, threatened,

or endangered in one or more states. There may be other rare or uncommon plants in Red Maple wetlands in Nova Scotia.

The diversity and rarity of lichens in Red Maple wetlands is notable. These species include some of the rarest lichens in the world, including globally endangered Boreal Felt Lichen. At least 15 other species of epiphytic cyanolichens have been found in association with Red Maple wetlands (Maass 1986; Cameron and Richardson 2006; Cameron and Neily 2008). Seven of these species are considered rare in North America (Brodo et al. 2001) or Canada (Goward et al. 1998), and three species may be extirpated or extremely rare in Maine (Hinds and Hinds 2007). Five species have recently been designated as "red" status and eight species designated as "yellow" status in Nova Scotia by the Nova Scotia Department of Natural Resources (Anderson 2007). Some of the other most notable species are *Erioderma mollissimum*, *Pannaria lurida*, *Degelia plumbea*, and *Sticta limbata*.

The diversity and rarity of *Sphagnum* species found in study plots are also remarkable. Twelve species of *Sphagnum*, including four Rare or Extremely rare species, were found in these wetlands. Most other studies of Red Maple wetlands have tended to ignore the *Sphagnum* community, lumping them together as "*Sphagnum* species". In a summary of research on Red Maple wetlands in the northeastern United States, Golet et al. (1993) list six species of *Sphagnum* in Red Maple swamps. Clearly, the *Sphagnum* community of Red Maple wetlands in eastern North America is unexplored, rich, and significant.

Indeed, the bryophyte and lichen communities in general may be little investigated but worth studying in Red Maple wetlands. Thirty-five species of bryophytes and lichens were found in this study. Golet et al. (1993) list only 36 species in total in their summary for the northeastern United States.

Given the diversity of vascular and non-vascular plant richness and structural complexity of Red Maple wetlands in Nova Scotia, these wetlands make a significant contribution to the biodiversity and heterogeneity of the landscape. Landscape managers and planners should ensure these unique and valuable wetlands are conserved.

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# Factors Affecting Pregnancy in Free-ranging Elk, *Cervus elaphus nelsoni*, in Michigan

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Uncertainty exists as to which factors are most closely related to probability of pregnancy in Elk (*Cervus elaphus*), which thresholds are key for managers who want to assess the potential productivity of free-ranging Elk herds, and whether these thresholds vary among populations. We examined relationships among pregnancy, age, and mass for 513 harvested free-ranging Elk in Michigan, and compared relationships with other published models and with thresholds derived from other free-ranging and penned populations to see if relationships were consistent among populations. Pregnancy rates varied ( $\chi^2_2 = 136.3$ ;  $P < 0.0001$ ) among yearling (0.30), prime-aged (2.5–11.5-year-olds; 0.88), and old ( $> 12.5$ -year-olds; 0.60) cows. Probability of pregnancy in adult cows was related to mass ( $\chi^2 = 7.4$ ;  $P = 0.006$ ), age ( $\chi^2 = 12.6$ ;  $P = 0.0004$ ) and age class ( $\chi^2 = 16.4$ ;  $P < 0.0001$ ), but not to lactation status ( $\chi^2 = 0.4$ ;  $P = 0.515$ ); pregnancy was also positively related ( $\chi^2 = 15.8$ ;  $P < 0.0001$ ) to mass in yearlings. Probability of pregnancy increased 1.02 $\times$  and 1.04 $\times$  for each 1 kg increase in body mass of adult and yearling cows, respectively, and prime-aged cows were 4.9 $\times$  more likely to conceive than old cows. Compared to thresholds derived primarily from penned or farmed Elk, both adult and yearling free-ranging Elk in Michigan and elsewhere were able to achieve higher levels of pregnancy at lower body mass. Thresholds also varied among free-ranging Elk populations. Given variation among populations, managers should calibrate mass–pregnancy relationships for their respective populations to determine whether condition is potentially limiting pregnancy in their populations.

Key Words: Elk, *Cervus elaphus*, age, pregnancy, mass, lactation, Michigan.

Elk (*Cervus elaphus*) and other populations grow only if population level productivity exceeds population level mortality (White and Bartmann 1997). Conception is the first step in population productivity, and many studies have demonstrated a link between age and condition and productivity in Elk (Clutton-Brock et al. 1982; Cook et al. 2004) and other ungulates (Verme 1969; Albon et al. 1983; Sæther and Haagenrud 1983; Anderson and Linnell 2000; Lomas and Bender 2007; Hamel et al. 2009). Juveniles, older females, and females in poor condition produce fewer young because of delayed sexual maturity, failure to ovulate or conceive, and/or the bearing of weaker neonates that do not survive to reproductive age (Verme 1969; Gaillard et al. 2000; Cook et al. 2004; Lomas and Bender 2007).

Uncertainty exists as to which factors are most closely related to probability of pregnancy in Elk, which thresholds are key for managers who want to assess the potential productivity of free-ranging Elk herds, and whether these thresholds vary among populations (Cook 2002; Raedeke et al. 2002). Further, it is important that these relationships be quantified for free-ranging Elk in a variety of geographic areas and habitat conditions. Most efforts to quantify pregnancy

relationships have used penned or farmed Elk herds (e.g., Hudson et al. 1991; Cook et al. 2004), but free-ranging and penned Elk live under extremely dissimilar conditions and may thus exhibit disparate relationships between body condition and pregnancy. Similarly, free-ranging populations differ in the quality of habitats occupied, which may affect condition, including absolute and relative size of Elk and the consequent likelihood of pregnancy (Clutton-Brock et al. 1982; Bender et al. 2003; Piasecke 2006). Because thresholds derived from a single population cannot indicate potential variation among populations, it is unknown whether existing models of pregnancy or thresholds actually apply across Elk populations. Consequently, our goals were (1) to determine relationships among pregnancy, age, and mass of adult and yearling cow Elk in Michigan and (2) to determine whether relationships in Michigan were similar to thresholds from models developed for other free-ranging populations and for penned populations.

## Study Area and Methods

### Study area

Our study population inhabited northern Great Lakes forest in the northern lower peninsula of Michigan



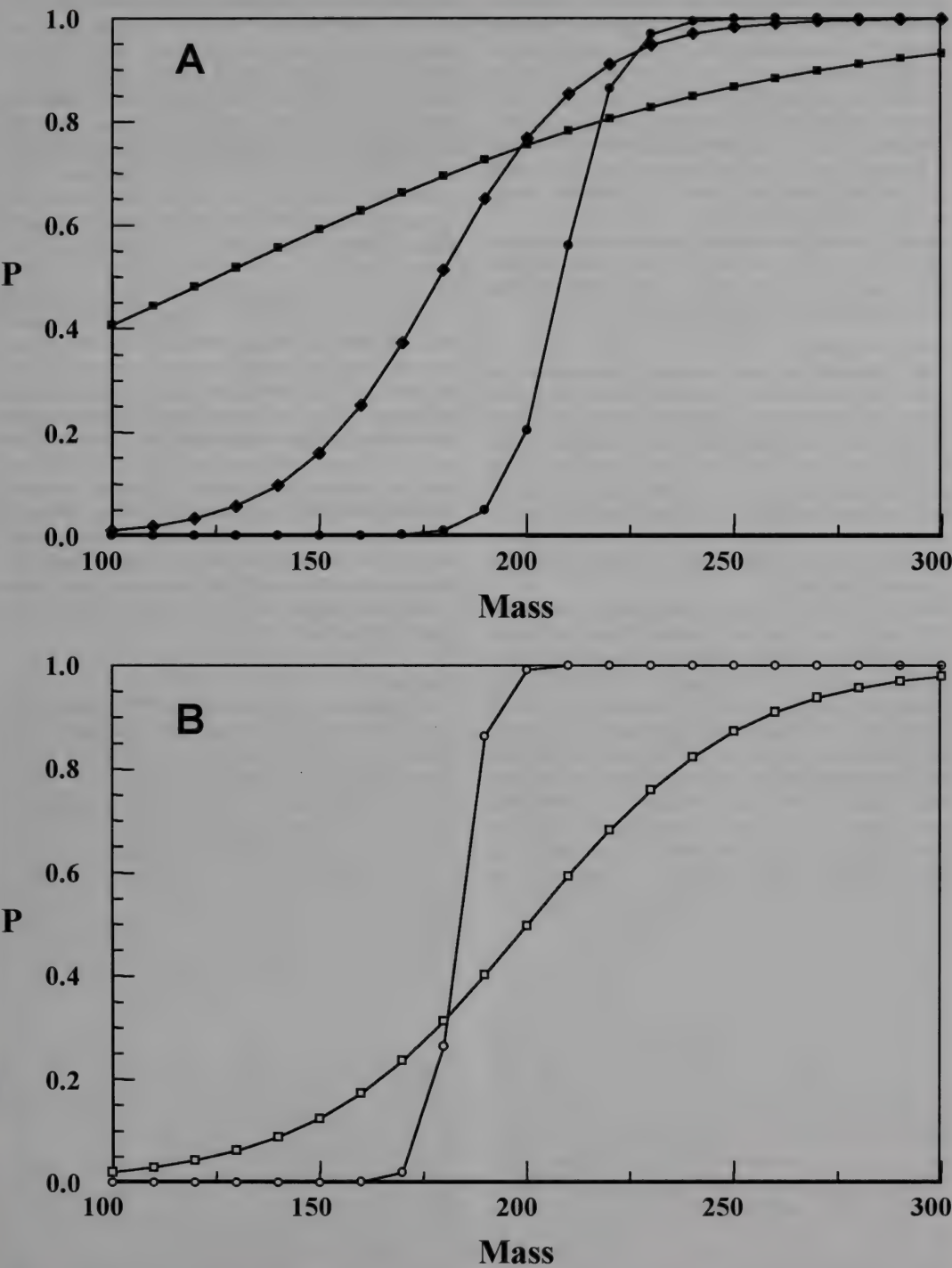


FIGURE 1. Probability of pregnancy for  $\geq 2.5$ -year-old (■; A) and yearling (□; B) Elk in Michigan as a function of body mass (kg) in late autumn. Also shown are models of adult pregnancy from northwestern New Mexico (♦; Piasecke 2006) and the Sacramento Mountains in south-central New Mexico (●; Halbritter 2007) and a model of yearling pregnancy developed from penned Elk (○; Cook et al. 2004).

(approximately 45°19'N, 84°18'W). Vegetation cover in the primary Elk range was mostly forest, with scattered agricultural land and wildlife openings. Approximately 79% was in forest cover types, primarily northern hardwoods, aspen (*Populus tremuloides* and *P. grandidentata*), pines (*Pinus* spp.), and coniferous swamps (Moran 1973). Temperatures ranged from a mean high of 26.7°C in July to a mean low of -13.3°C in January. Mean annual precipitation was 90 cm, with 56% falling from May through September. Mean annual snowfall was 380 cm.

Elk in Michigan were not migratory. During our study, Elk density was  $\leq 0.7$  Elk/km<sup>2</sup> and bull/cow ratios averaged 56/100 (Bender 1992). Greater than 40% of bulls were > 4.5 years old (Bender 1992).

#### Data collection

We collected data from harvested Elk examined at mandatory hunter check stations or at kill sites which were marked by hunters in the field in early December. We aged Elk to the exact year using cementum annuli from an extracted tooth or to approximate year using tooth eruption and wear (Keiss 1969). We also placed Elk into three categories, yearling (age 1.5), prime-aged (2.5–11.5 years), or old ( $\geq 12.5$  years), to test for differences among age classes (Bertouille and de Crombrughe 2002).

We determined pregnancy status and the proportion of cows that were pregnant (number of pregnant cows/total number of cows sampled) for yearling, prime-aged, and old cow Elk, December 1984–1991, using serum progesterone levels determined from blood samples collected during December hunts, which usually occurred during the first week of December. Elk with serum progesterone levels of 1.0 ng/mL or higher were considered pregnant (Bender et al. 2002). We determined lactation status for adult cows by inspecting either Elk gut-piles or remaining mammary tissue on hunter-harvested Elk, 1984–1991. Mammary tissue still secreting milk indicated that the harvested cow was either still nursing a calf or had been nursing a calf within 3–11 days (Bender et al. 2002).

We estimated live body mass from hunter-dressed carcasses where live body mass equalled hunter-dressed carcass mass divided by 0.67. We used this correction because it was developed from the same subspecies of Elk (*C. e. nelsoni*) during the same time period, both temporally (December) and with respect to annual Elk body condition patterns, as our study in Michigan. Although variation exists in correction factors, much of this variation is due to subspecies differences and seasonal differences, such as differing seasonal body condition and feeding rates (Bender et al. 2003).

#### Data analysis

We compared mean body mass of Elk by age class among years and between age classes using ANOVA (Zar 1996). We compared pregnancy rates among age classes and years using contingency tables (Zar 1996).

We used logistic regression to model the dichotomous outcome of pregnancy (i.e., pregnant, not pregnant) for adult cows as a function of age, age class, lactation status, and mass (Hosmer and Lemeshow 1989). We compared fit of models using Akaike's Information Criterion (AIC), the Schwarz Criterion (SIC), pseudo- $R^2$ , and model concordance (Hosmer and Lemeshow 1989; Burnham and Anderson 1998). We similarly modeled probability of pregnancy for yearling cow Elk as a function of body mass only, because yearlings would not show differing lactation status as Elk do not breed as calves (Raedeke et al. 2002).

We compared predictive models from Michigan with previously published models or thresholds of Elk pregnancy for Rocky Mountain Elk for age and mass. We used randomization tests to compare models by generating  $N = 1000$  values for each parameter using the mean and standard error, calculating a difference vector for each paired comparison, and calculating the number of extreme values out of the  $N = 1000$  possible to determine the probability that the estimates differed (Bender and Hall 2004). When published models did not include standard errors of estimates, we used 90% confidence intervals around our parameter estimates to see if the parameters from extant models fell within these CIs. If they did not, the models differed at  $P < 0.10$ .

#### Results

We gathered data from a total of 513 (420 adult, 93 yearling) Elk that were harvested by hunters from 1984 to 1991. Neither yearling ( $F_{6,68} = 1.4$ ;  $P = 0.222$ ), prime-aged ( $F_{6,319} = 1.6$ ;  $P = 0.144$ ), nor old ( $F_{5,25} = 0.7$ ;  $P = 0.613$ ) cows varied in body mass among years, so we pooled data for comparisons among age classes. Mass differed ( $F_{2,429} = 175.9$ ;  $P < 0.001$ ) among age classes: yearlings ( $P < 0.001$ ) were lighter than prime-aged or old cows, which did not differ ( $P = 0.949$ ) in mass (Table 1). Similarly, pregnancy rates did not vary among years for yearlings ( $\chi^2_6 = 2.2$ ;  $P = 0.889$ ), prime-aged ( $\chi^2_6 = 2.8$ ;  $P = 0.830$ ), or old ( $\chi^2_5 = 5.3$ ;  $P = 0.383$ ) cows, so we pooled data over years for the following tests. Pregnancy rates differed by age class ( $\chi^2_2 = 136.3$ ;  $P < 0.0001$ ). Prime-aged cows had higher pregnancy rates than yearlings ( $\chi^2_1 = 135.5$ ;  $P < 0.0001$ ) or old cows ( $\chi^2_1 = 22.0$ ;  $P < 0.0001$ ), and old cows also had higher pregnancy rates ( $\chi^2_1 = 8.9$ ;  $P = 0.003$ ) than yearlings (Table 1).

For individual adults, age ( $\chi^2 = 12.6$ ;  $P = 0.0004$ ), age class ( $\chi^2 = 16.4$ ;  $P < 0.0001$ ), and body mass ( $\chi^2 = 7.4$ ;  $P = 0.006$ ) were related to probability of conceiving, but lactation status ( $\chi^2 = 0.4$ ;  $P = 0.515$ ) was not (Table 2). The best supported model included mass, and odds ratios indicated that the probability of pregnancy increased 1.02× for each 1 kg increase in body mass (Figure 1). Odds ratios also indicated that prime-aged cows were 4.86× more likely to conceive



TABLE 1. Proportion (SE) of pregnant cow Elk and mean body mass (SE) of free-ranging Elk in Michigan by age class.

	1.5		Age (years)		≥12.5	
	$\bar{x}$	<i>n</i>	$\bar{x}$	<i>n</i>	$\bar{x}$	<i>n</i>
Pregnant	0.31 (0.03) <sup>a</sup>	93	0.88 (0.01) <sup>b</sup>	382	0.60 (0.09) <sup>c</sup>	37
Mass (kg)	177.2 (3.6) <sup>a</sup>	75	241.8 (1.4) <sup>b</sup>	326	249.2 (6.2) <sup>b</sup>	31

Means with the same letter are not significantly different (*P* > 0.05).

TABLE 2. Variable  $\chi^2$  score and associated probability, Akaike (corrected for small sample size) and Schwartz information criteria (AICc and SIC), model *R*<sup>2</sup>, model concordance (Con), slope parameter estimates ( $\beta$  and SE), and odds ratios (95% CI) for logistic models of pregnancy for Elk cows ≥ 2.5 years old in Michigan.

Variable	$\chi^2$	<i>P</i>	AICc	SIC	<i>R</i> <sup>2</sup>	Con	$\beta$ (SE)	Odds ratio (95% CI)	<i>n</i>
Mass	7.3	0.007	315	318	0.35	60	0.015 (0.005)	1.02 (1.01–1.04)	357
Age	13.4	<0.001	353	357	0.05	53	–0.115 (0.032)	0.891 (0.838–0.948)	419
Age class	18.3	<0.001	353	357	0.07	23	0.791 (90.185)	4.86 (2.36–10.02)	419
Lactation status	0.4	0.511	268	272	0.0002	25	0.109 (0.165)	1.24 (0.65–2.38)	306

than old cows, and that overall probability of pregnancy was 1.14× less likely for each additional year of age. Probability of pregnancy was also positively ( $\beta$  = 0.0388 [SE = 0.116]) related ( $\chi^2$  = 15.8; *P* < 0.0001) to body mass of yearling cows (*n* = 75). Odds ratios (1.04; 95% CI = 1.02–1.06) indicated that the probability of pregnancy increased 1.04× for each 1 kg increase in yearling body mass (Figure 1).

Predictive models of pregnancy as a function of body mass differed between Michigan and models for free-ranging Elk in northwestern New Mexico (*P* ≤ 0.048; Piasecke 2006) and Elk in the Sacramento Mountains of New Mexico (*P* ≤ 0.020; Halbritter 2007) (Figure 1A), and these two models also differed (*P* ≤ 0.10). Models of yearling pregnancy in Michigan differed from a model developed from penned yearling Elk (Cook et al. 2004; constant = –52.688,  $\beta$  = 0.287, *P* < 0.10) based on exclusion of the Cook et al. (2004) coefficients from the 90% CIs of model coefficients for Michigan; free-ranging yearlings in Michigan were more likely to conceive at lower mass (Figure 1B).

### Discussion

Both mass and age of individuals affected pregnancy in free-ranging Elk in Michigan, similar to other large mammal populations (Samson and Huot 1995; Bérubé et al. 1999; Solberg et al. 2002; Nahlik and Sandor 2003), including Elk (Hudson and Haigh 2002). The best overall predictor of pregnancy was body mass (Table 2). Mass reflects total energy reserves available to Elk (i.e., total fat and muscle reserves), which may be more important to pregnancy than relative measures such as percentage body fat (Frisch 1984; Piasecke 2006). Further, mass typically increases with age until reproductive senescence occurs (Bender et al. 2003). Our results thus support other general conclusions that

show that cows in better condition (i.e., more total mass, fat, muscle) or more dominant cows (usually larger) are more likely to be pregnant (Clutton-Brock et al. 1982; Frisch 1984; Hudson and Haigh 2002; Cook et al. 2004), and refute others that say mass has no effect on pregnancy (Willard et al. 1994). Work with other large mammals (for example, bears [*Ursus americanus*; Samson and Huot 1995], Bighorn Sheep [*Ovis canadensis*; Bérubé et al. 1999], Moose [*Alces alces*; Solberg et al. 2002], Wild Boar [*Sus scrofa*; Nahlik and Sandor 2003]) has similarly found that size or total body reserves are important in pregnancy and total reproductive effort (i.e., numbers of offspring successfully produced).

Previously, conception in adult Elk has been thought to be precluded when cows weigh < 200 kg; at approximately 260 kg, the pregnancy rate is > 90% (Haigh and Hudson 1993). In Michigan, the pregnancy rate rose above 90% at ≥ 275 kg and was still > 60% at approximately 160 kg (Figure 1A), the smallest adult cow we observed in Michigan. This lower mass threshold was lower than thresholds previously postulated, which were based on farmed Elk. Work with Red Deer (*C. elaphus*) also revealed strong relationships between pregnancy and mass (Albon et al. 1983; Bertouille and de Crombrughe 2002), although weights cannot be directly compared with our data because of subspecies differences.

Similarly, our data showed that yearlings were more likely to be pregnant at lower mass and less likely at higher mass than penned Elk (Cook et al. 2004). In our study, predicted yearling pregnancy did not reach 90% until mass had risen above 257 kg in Michigan; Cook et al. (2004) found yearling pregnancy of > 90% at 195 kg. Conversely, yearling pregnancy did not drop below 10% until the 145 kg level in Michigan,

as compared to approximately 175 kg with penned yearlings (Cook et al. 2004) (Figure 1B).

In contrast, there were fewer differences between our data and previous studies of free-ranging Elk. In Yellowstone, yearling cows did not conceive when they were < 152 kg, 10% were pregnant at 152–163 kg, and 25% were pregnant at 163–169 kg (Greer 1968). At those masses, approximately 13, 13–19, and 19–23% of yearlings in Michigan were predicted to be pregnant, respectively. Thresholds for yearling pregnancy of 180 kg (Cook et al. 2004) and 190 kg (Hudson et al. 1991) found for penned Elk were also higher than we observed for free-ranging elk in Michigan; > 31% of yearlings in Michigan were predicted to breed at 180 kg (Figure 1B), and 26% (8/31) actually did. Pregnancy in yearlings exceeded 10% at approximately 145 kg, suggesting that this value may be a more robust threshold for free-ranging Elk. This was approximately 60% of the average body mass of cows  $\geq$  2.5 years old in our study (242 kg). This proportion was also lower than a previously proposed yearling mass threshold (70%), again from a study on penned Elk (Hudson and Haigh 2002).

Different mass thresholds necessary for pregnancy among free-ranging populations (Figure 1) illustrate that, although the probability of pregnancy rises with mass, the actual relations are population-specific; thus data from a single population should not be generalized to all Elk populations. This agrees with the hypothesis that Elk, particularly yearlings, may not have a specific mass that must be reached in order to conceive, but that they must reach a certain proportion of their adult weight (Haigh and Hudson 1993), which varies by population (Bender et al. 2003). Moreover, published thresholds derived from penned or farmed Elk populations should not be used to assess the performance potential of free-ranging Elk, as threshold levels were always much higher for penned or farmed Elk than for free-ranging Elk. Penned Elk may require better levels of condition than free-ranging Elk because of a loss of fitness due to captivity or domestication (Leopold 1944).

Certainly free-ranging Elk confront much different foraging, survival, and other challenges than penned Elk, which face no competition, predation, or debilitation (due to veterinary care), do not have to spend time searching for food, and encounter minimal disturbance. The process of captivity or domestication itself may alter phenotypic or genotypic quality of animals (Leopold 1944). These issues can affect free-ranging populations as well; for example, yearlings and cows  $\geq$  2.5 years old in Michigan may not have performed as well at the higher ends of condition as Elk in penned studies because of factors such as disease, which could interfere with reproductive ability or cause fetal loss. Fetal loss is rare but present in free-ranging Elk (approximately 3.7% [SE = 1.8%]; Piasecke 2006), and some diseases or other harmful factors may prevent conception from occurring.

Pregnancy is also affected by the age structure of a population (Table 2; Clutton-Brock et al. 1982; Gaillard et al. 2000; Raedeke et al. 2002). This effect could be particularly important in populations in excellent condition, because when no nutritional stress is occurring, only extreme youth or age might limit individual reproduction. Although prime-aged cows in Michigan were 4.9 $\times$  more likely to be pregnant than old cows, pregnancy rates of old cows (60%) were generally higher in Michigan than were reported elsewhere for Rocky Mountain Elk (< 50%; Raedeke et al. 2002). Higher rates of pregnancy in old cows in Michigan may have been a result of high body condition (Bender et al. 2003). Lactation status had no effect on probability of pregnancy in adult cows in Michigan (Table 2), whereas successfully raising a calf can result in lowered probability of pregnancy for malnourished cows (Cook 2002; Raedeke et al. 2002; Piasecke 2006). However, high nutrition can likely only limit reproductive senescence to a degree. In Michigan, old cows were able to maintain relatively high (77%) pregnancy until age 18.5 years, but we found no pregnant cows aged 19.5–22.5, the oldest age we observed in Michigan.

## Implications

Mass was the best predictor of pregnancy in Michigan, similar to results from other free-ranging populations (Piasecke 2006), likely because mass indexes both total body reserves and age effects. Relationships vary among populations, however, because of differences in habitat quality, genetics, etc., and their consequent influences on size. Managers should develop or calibrate mass–pregnancy curves for their local populations to assess pregnancy relationships for accurate predictions. Managers should also be aware that mean pregnancy rate is not a sensitive indicator of mean condition of an Elk herd, because it can be confounded by factors such as age structure of the population.

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# Wolf, *Canis lupus*, Avoidance Behaviour of American Elk, *Cervus elaphus*, in Jasper National Park, Alberta

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Dekker, Dick, and Greg Slatter. 2009. Wolf, *Canis lupus*, avoidance behaviour of American Elk, *Cervus elaphus*, in Jasper National Park, Alberta. *Canadian Field-Naturalist* 123(3): 236–239.

An American Elk calf (*Cervus elaphus*) that was captured near human habitation in Jasper National Park, Alberta, was fitted with a radio-collar and released 40 km away in the park's main valley of the Athabasca River. The calf joined a local herd of elk, and its radio signal revealed that the elk, in two months' time, travelled eight times back and forth between the herd's traditional semi-open winter range at Devona and a largely wooded area at Rocky River >3 km away. Each time, on their trans-valley route the elk crossed a busy highway, a railway, and a partly frozen river. Sightings of elk and Wolves (*Canis lupus*) were inversely correlated on 97 days of observation at Devona. We conclude that the elk's migrations were prompted by their urge to avoid and flee from Wolves, which were common at both locations.

Key Words: American Elk, *Cervus elaphus*, Wolves, *Canis lupus*, interactions, Jasper National Park, Alberta, Canada.

Predation has been the subject of numerous studies in a variety of taxa with the principal objective of determining what predators kill. However, more recent research has focussed on the indirect effect of predation, which is believed to have an impact on prey behaviour, mediated by fear, that may be more important than the number of prey killed (Brown and Kotler 2007). For instance, migrating shorebirds were found to avoid feeding sites near vegetation behind which hunting falcons could conceal their approach and take the prey by surprise (Dekker 1998a; Ydenberg et al. 2004). For birds, the trade-off is that safety usually comes at the cost of a lower food intake and an increase in energy expenditure (Lima and Dill 1990). Similarly, predation by large carnivores is considered a major determinant in the demographics of ungulate populations (Mech and Peterson 2003), but avoiding predation was found to be costly in terms of reproductive physiology as well as demographics (Creel et al. 2007). In Yellowstone National Park, after Wolves (*Canis lupus*) were reintroduced, American Elk (*Cervus elaphus*) retreated into woodlands, which may be safer but poorer in forage (Mao et al. 2005). In Canadian National Parks, where Wolves occur and hunting is not permitted, elk become habituated to humans and – as an anti-predator strategy – gravitate towards buildings and roads. In Jasper National Park (JNP), 50–60% of the summer population and 80% of the winter population of elk are concentrated near the Jasper town site and along major roads, presumably because large carnivores are less common than in the backcountry (Dekker et al. 1995). As a result, forage plants in these heavily utilized zones become overgrazed and damaged. In addition, aggressive elk cause problems near the town.

With the objective of preventing human/elk conflict and reducing grazing pressure, JNP staff began a program of capturing elk near the town and tourist facilities to relocate them elsewhere, either within or outside JNP. This management method proved only partially successful, because most adult elk eventually returned to the site of capture. On 31 January 2000, hoping for better results with young animals, JNP staff trapped an additional 11 elk, of which 10 were calves. To monitor their wanderings, one of the female calves was equipped with a loose-fitting neck collar and a Lotek VHF radio-transmitter. The calf was set free at Rocky River, 40 km northeast of the original capture site. In this note, we report on the results.

## Study Area and Methods

JNP is 10 880 km<sup>2</sup> in size and situated in west-central Alberta between latitude 52°29' and 52°08'. Elevations range from 3747 m in the west to 990 m in the east. For a complete inventory of ecotones, flora, and fauna of JNP, see Soper (1970) and Holroyd and VanTighem (1983).

The study site is located in the lower valley of the Athabasca River, between two of its major tributaries: the Rocky River, flowing in from the east, and the Snake Indian River entering from the northwest. The valley bottomlands on the west side of the river are called the Devona Flats. Roughly 3–4 km wide, they are characterized by a mosaic of semi-open montane meadows and mixed woods of conifers, willow (*Salix* spp), and Trembling Aspen (*Populus tremuloides*). The Devona Flats are the traditional wintering range of the Devona elk herd, consisting of cows, calves, and yearlings of both sexes. Based on records obtained over 20 consecutive winters in 1981–2001, the mean size of



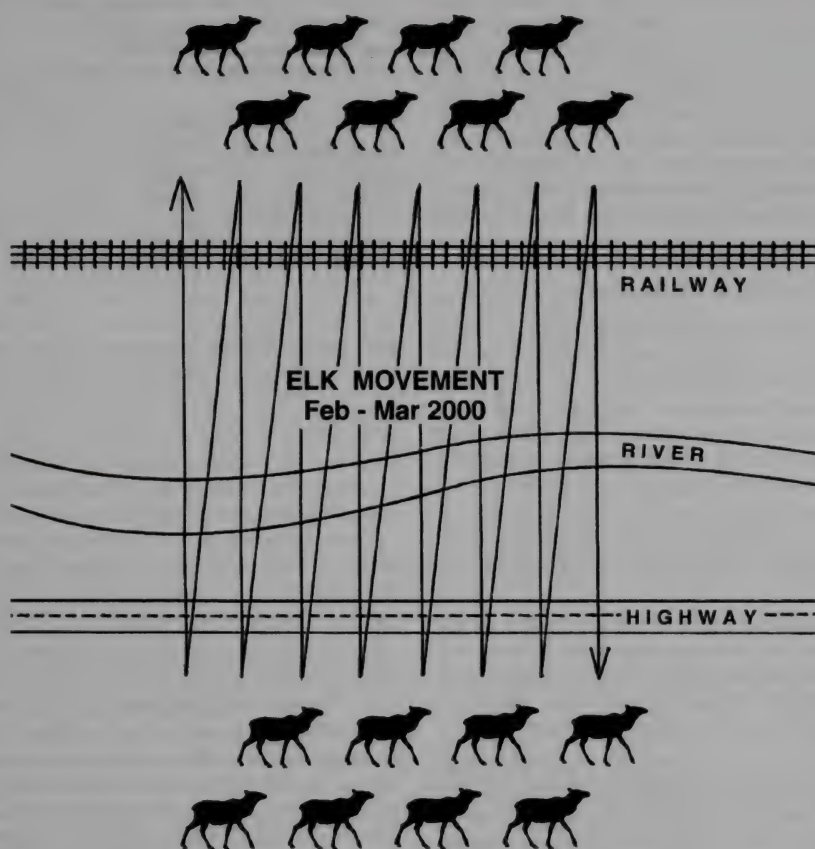


FIGURE 1. The signals of a radio-collared elk calf travelling with the Devona elk herd indicated that they switched back and forth between Devona and the valley of the Rocky River eight times during February and March 2000. The one-way distance was  $>3$  km and involved crossing a railway, the Athabasca River, and the busy Yellowhead Highway.

the Devona cow/calf herd was calculated at 49, and the mean number of mature bulls at 16 (Dekker 2006\*).

Between October and March, 2000-2009, DD visited the Devona elk winter range 36 times. Each visit included 1-3 overnights and the total number of observation days was 116. Near sunrise and sundown, he ascended a hillside vantage point and spent one hour or more scanning the semi-open meadows and river flats through binoculars. During the day, he traversed the study area on foot. Elk and Wolf presence were determined by sightings and tracks (Dekker 1998b, 2002).

The Athabasca Valley is the main traffic corridor for the Canadian National Railway and the busy transcontinental Yellowhead Highway (ca 4000 vehicles/day). In 2000-2008, the annual mean of ungulate casualties on the highway was 107 ( $r = 94-127$ ). Ungulate casualties on the railway ranged from 37 to 62 per annum with a mean of 52.

On the day of capture, 31 January 2000, the collared elk calf was released on the east side of the Yel-

lowhead Highway just above the confluence of the Rocky River with the outlet of Jasper Lake, which is a shallow widening of the Athabasca River. To monitor its subsequent migrations, one of us (GS) determined the calf's location by the signals received through a hand-held antenna (Communication Specialists Inc.).

## Results and Discussion

Within days of its release, the collared calf joined the Devona elk herd and stayed with that herd until the calf became a traffic casualty on the highway. Its radio signal was picked up 124 times. Between 1 February and 31 March 2000, its location switched between the Devona Flats on the west side of the valley to the lower Rocky River east of the highway, a distance of  $>3$  km. Traveling between these two opposite points, the elk had to cross the railroad and the Yellowhead Highway, as well as the Athabasca River. The river crossing traditionally took place at the outlet of Jasper Lake, a circa 80 m wide channel of swift water that

stays open most of the winter. During February and March 2000, the tagged elk calf and its herd travelled back and forth eight times between the Devona Flats and Rocky River, on average 3.9 days apart (1). During these same two months, DD visually checked the Devona winter range on 11 dates. On three days, the elk herd, including the collared calf, was present on the Flats, and no recent sign of Wolves was found. By contrast elk were absent on six days when Wolves or their fresh tracks were recorded. On two days neither Wolves nor elk were seen.

During the winters of 2001-2009, DD spent all or part of 116 days on the Devona Flats. On 61 days, Wolves were seen, heard, or tracked, and the Devona cow/calf elk herd was absent. By contrast, the herd was seen on 36 days when no wolf sign was found along the pack's habitual travel routes. The presence of Wolves and elk was inversely correlated with a highly significant degree of probability ( $P < 0.000001$ ). On 12 days, or part thereof, both Wolves and elk were in the area; on the remaining 7 days snow cover was insufficient for tracking and neither elk nor Wolves were seen (Table 1).

We believe that the reason for the trans-valley migrations of the elk was Wolf avoidance. In the winter of 1999-2000, the Devona Flats were part of the territory of a pack of 8-11 Wolves. In other years, there was a second pack of 2-4 Wolves (Dekker 1998b, 2002).

Although we never observed Wolves in the act of making a kill, we saw them pursue elk that fled into the woods. Some hard-pressed elk made a stand in turbulent rivers or on steep ground. Similar defensive tactics of elk were recorded by other observers in JNP or in adjacent Alberta forests (Cowan 1947; Van Tighem et al. 1980; Kansas 1981; Schmidt and Gunson 1985). Remains of elk evidently preyed upon by Wolves were occasionally found in the woods or on frozen water courses. As determined by fresh tracks, some elk chased by Wolves broke through river ice and drowned. Others became casualties on the railway and highway. Elk (and deer) chased by Wolves appeared oblivious to other dangers and ignored people (Dekker 1997; and unpublished data).

During the winters of 2000-2009, the Devona Wolf pack travelled back and forth between Devona and Rocky River roughly along the same route as the elk herd. As reported by wardens and members of the public, packs of Wolves were occasionally seen crossing the Yellowhead highway in either direction. The Devona pack, as identified by numeric and pelage characteristics, was photographed at Rocky River by Brian Genereux (wildlife photographer). Travelling between Devona and Rocky River, the Wolves either crossed frozen Jasper Lake or swam the open outlet. In some years, there were two different Wolf packs on opposite sides of the Athabasca River.

In conclusion, our findings suggest that the Devona elk herd and its radio-tagged calf departed their traditional wintering range to avoid Wolves. The reason

TABLE 1. Presence of American Elk and/or Wolves on the Devona elk winter range in Jasper National Park, Alberta, during the winters of 2000-2009.

	Observation days
Wolves in area but no elk herd	61
Elk herd in area but no Wolves	36
Both Wolves and elk present	12
Neither Wolves nor elk in area	7
Total observation days	116

why the elk herd kept returning to the Devona Flats, after having been chased out of there, can be explained by: (1) the superior grazing on the montane meadows compared to the mostly wooded terrain on the other side of the valley; (2) the tendency of elk to seek out Devona's open terrain because approaching predators can be spotted early; and (3) the elk were chased back to Devona and away from Rocky River by Wolves.

Changes in elk habitat preference, purportedly to avoid Wolves, were also reported from Yellowstone National Park and Montana (Mayo et al. 2005; Ripple and Beschta 2003; Creel et al. 2005). However, while noting that elk prefer open range because of better grazing, Winnie and Creel (2006) thought that open country was dangerous for elk because more Wolf kills were found in the open than in the woods, although the researchers were puzzled by their observation that the elk showed less vigilance in the open. In our view, a lower level of vigilance should be expected on open terrain because of better visibility. A parallel situation involves shorebirds that favour mudflats away from obstructive vegetation so as to avoid surprise attacks by falcons (Dekker 1998a, Dekker and Ydenberg 2004). At Devona, the local elk herd was extremely shy of people and easily spooked by humans as well as Wolves. This is in marked contrast to the behaviour of human-habituated elk that remain near the Jasper town site and along major roadways, where grazing opportunities as well as visibility have been enhanced by tree clearing.

A very different antipredator strategy of the Devona elk comes into play during spring and early summer. Then, pregnant cows shun open terrain and hide on densely forested islands in the lower Athabasca River. Nevertheless, predation on the young appears to be heavy. As determined by a large sample of early winter counts, the cow/calf ratio of the Devona herd is 100/19 as compared to 100/48 for elk that remain all year near the Jasper town site and along major roadways (Dekker et al. 1995).

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# Vascular Plant Diversity in Burned and Unburned Alvar Woodland: More Evidence of the Importance of Disturbance to Biodiversity and Conservation

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Catling, Paul M. 2009. Vascular plant biodiversity in burned and unburned alvar woodland: more evidence of the importance of disturbance to biodiversity and conservation. *Canadian Field-Naturalist* 123(3): 240–245.

Vascular plant biodiversity was compared in an unburned semi-open alvar woodland dominated by conifers and an equivalent woodland that had burned nine years previously and had developed into a long-lasting successional shrubland. The comparison, based on 30 quadrats 1 m<sup>2</sup> at each of two sites, revealed less than 25% similarity in the vegetation cover of the two sites. The successional alvar shrubland that developed following fire had twice as many species and more regionally rare species than the corresponding woodland site. The shrubland also had higher values for various biodiversity measures that take heterogeneity and evenness into account. These data provide additional evidence for the importance of fire and disturbance in the creation of successional habitat upon which biodiversity depends. A cautious use of fire in management of alvars is supported.

**Key Words:** vascular plant, alvar, biodiversity, rare species, disturbance, fire, succession, Simpson's Index, Shannon-Wiener function, Brillouin's Index, Smith and Wilson evenness, Ontario.

A number of articles have featured the beneficial effect of fire on rarer vascular plants and overall plant biodiversity on the Burnt Lands Alvar (Brunton 1986\*; Catling and Brownell 1999; Catling et al. 2001, 2002; Catling and Sinclair 2002) and have suggested that the removal of biomass on a large scale may contribute significantly to the protection of biodiversity on alvars (e.g., Catling et al. 2001, 2002). These articles were based on studies within a year after a fire and 37 years after a fire. Here diversity of vascular plants is compared in two sites: (1) a semi-open woodland dominated by conifers and (2) successional shrubland resulting from a fire nine years previously that had replaced woodland corresponding to, and nearly adjacent to, the woodland at site 1. The description of these two habitats has additional importance since they have been utilized in comparisons (published elsewhere) of insect biodiversity based on sampling with pitfall traps and nets.

## Methods and Materials

### *The study area*

The woodland study site in West Carleton, City of Ottawa, ca. 4.6 km east-northeast of Almonte (Lanark County), Ontario, included 4 ha (approximately 10 acres) centred on 45.2569°N, –76.1437°W. The corresponding burned woodland study site 0.5 km to the southeast also included 4 ha, centred on 45.2507°N, –76.1337°W. Based on personal observation prior to the fire, examination of pre-fire aerial photographs, and determination of identity of burned trees, both of these study areas had been semi-open, mixed forest dominated by conifers until 23 June 1999, when a fire swept through 152 ha, including the southern study

site. Both sites appeared to be similar in their vegetation throughout prior to the fire and both were of similar and unchanging elevation. At the time of the study, both sites were surrounded by similar vegetation for 100 m on all sides, the burned site by burned woodland and the unburned site by unburned woodland. At both sites, prior to the fire, the semi-open woodland was dominated by (in order of importance) *Thuja occidentalis*, *Picea glauca*, *Populus tremuloides*, *Abies balsamea*, and *Pinus strobus*, with an understory of mosses, including *Hylocomium splendens* and *Dicranum polysetum*, and occasional depauperate shrubs, including *Juniperus communis*. This is believed to be climax vegetation for these sites, since some trees are killed by drought leading to recolonization of the early successional tree species. The area has long been known to be particularly subject to fire, and it was named the Burnt Lands by settlers in 1870, at the time of the second most recent fire. For more information on this area, see White (1979), Brunton (1986\*), and Catling et al. (2001, 2002).

### *Description of the vegetation*

In August 2008, 30 quadrats 1 m<sup>2</sup> were placed approx. 3 m apart along a transect through the centre of each site. One was placed directly over each of ten pitfall insect traps (at each site) and the other two were placed 2 m away. Thus there were 30 quadrats of 1 m<sup>2</sup> in each of the burned woodland and the unburned woodland. For each quadrat the percentage cover (represented by half of the surface area) of all plants to 1 m tall was estimated for each species of vascular plant, for bryophytes as a group, and for lichens as a group. The two sites were compared with regard to





FIGURE 1. Burned (left) and unburned (right) alvar woodland on the Burnt Lands Alvar in western Ottawa. On the left, fallen and dead standing trees are *Abies balsamea*, *Picea glauca*, *Pinus strobus*, and *Thuja occidentalis*. Regrowth on upper left is *Populus tremuloides*, and *Arctostaphylos uva-ursi* can be seen flowering in the foreground. In the right-hand photograph, the forest is dominated by *Abies balsamea*, *Picea glauca*, *Pinus banksiana*, *Pinus strobus*, *Populus tremuloides*, and *Thuja occidentalis*. Shrubs of *Juniperus communis* are present in the foreground. The photo on the left showing the area burned on 23 June 1999 was taken at 45.2507°N, -76.1437°W. The photo on the right was taken at 45.2569°N, -76.1437°W. (Photos: P. M. Catling, late May 2008)

the dominant species (frequency and cover) and biodiversity and to the value to pollinating insects. The plants were identified using Fernald (1950) and the online Flora of North America series (Flora of North America 1993-2009), and the names mostly follow the recent compilation of Kartesz and Meacham (1999). Vouchers of vascular plants are preserved in the National Collection of Agriculture and Agri-Food Canada in Ottawa (DAO), and vouchers of lichens and mosses are in the collection of the Canadian Museum of Nature (CAN).

#### Comparison and biodiversity measures

Sites were compared to determine the extent of distinctness, since sites that are more distinct would have higher biodiversity value. This aspect was evaluated with regard to the number of species in common and the percentage of the total cover provided by those common species (at both sites) compared to the combined cover of all species at both sites.

The two sites were also compared with respect to the presence of rare and restricted species. Regional rarity was determined by reference to the list of regionally rare species developed by Brunton (2005\*).

The measures of biodiversity employed here for comparison were (1) total number of species and the frequency and cover of each species; (2) the reciprocal of Simpson's Index based on probability which weights common and dominant species; (3) the exponential form of the Shannon-Wiener function that is based on information theory and weights rare species more heavily; (4) Brillouin's Index, which employs numbers of individuals or, in this case, instances (i.e., frequency), and assumes no replacement; and (5) the Smith and Wilson evenness measure, which is sensitive to both rare and common species and is independent of species richness. These widely employed measures are all described by Krebs (1999); associated software was used for the computations (Krebs 2008\*).

#### Results

The unburned site was a semi-open forest with dominant trees being (in order of importance) *Thuja occidentalis*, *Picea glauca*, *Populus tremuloides*, *Abies balsamea*, and *Pinus strobus*. The understory was dominated by *Carex eburnea* and bryophytes, mostly *Hylo-*

TABLE 1. Plant species with average cover and frequency values for plants less than 1 m tall in unburned semi-open alvar woodland. The tree cover was dominated by (in order of importance) *Thuja occidentalis*, *Picea glauca*, *Populus tremuloides*, *Abies balsamea*, and *Pinus strobus*. The species are arranged in descending order of average percentage cover value, then by frequency, then alphabetically. The data are based on 30 quadrats 1 m<sup>2</sup> at least 2 m apart sampling an area of 4 ha. Species marked with two asterisks (\*\*) are regionally and/or provincially rare. Species marked with + are introduced.

Species	Average % Cover	Frequency
Bryophytes (mostly <i>Pleurozium schreberi</i> and <i>Dicranum polysetum</i> )	42.50	27
<i>Carex eburnea</i> Boott, Bristle-leaf Sedge	40.26	23
<i>Carex richardsonii</i> R. Br., Richardson's Sedge **	8.10	21
<i>Symphoricarpos albus</i> (L.) Blake, Common Snowberry	6.00	19
<i>Arctostaphylos uva-ursi</i> (L.) Spreng., Red Bearberry	4.53	13
<i>Juniperus communis</i> L. var. <i>depressa</i> Pursh, Common Juniper	3.70	5
<i>Waldsteinia fragarioides</i> (Michx.) Tratt. ssp. <i>fragarioides</i> , Appalachian Barren-Strawberry	2.03	10
<i>Prunella vulgaris</i> L., Common Selfheal	1.96	6
<i>Oryzopsis asperifolia</i> Michx., White-grain Mountain-Rice Grass	1.60	17
<i>Symphotrichum</i> (Aster) <i>ciliolatum</i> (Lindl.) A. & D. Löve, Lindley's American-Aster	1.30	6
<i>Abies balsamea</i> (L.) P. Mill., Balsam Fir	1.06	6
lichens (unidentified)	1.00	3
<i>Thuja occidentalis</i> L., Eastern Arborvitae	0.90	6
<i>Maianthemum canadense</i> Desf., False Lily-of-the-Valley	0.66	6
<i>Rosa acicularis</i> Lindl. ssp. <i>sayi</i> (Schwein.) W. H. Lewis, Prickly Rose	0.63	8
<i>Aquilegia canadensis</i> L., Red Columbine	0.60	8
<i>Fragaria virginiana</i> Duchesne ssp. <i>virginiana</i> , Virginia Strawberry	0.46	7
<i>Picea glauca</i> (Moench) Voss, White Spruce	0.43	4
<i>Danthonia spicata</i> (L.) Beauv. ex Roemer & J. A. Schultes, Poverty Wild Oat Grass	0.33	6
<i>Shepherdia canadensis</i> (L.) Nutt., Russet Buffalo-Berry	0.26	3
<i>Rhamnus cathartica</i> L., European Buckthorn +	0.20	3
<i>Frangula alnus</i> P. Mill., Glossy False Buckthorn +	0.20	4
<i>Toxicodendron</i> ( <i>Rhus</i> ) <i>rydbergii</i> , (Small ex Rydb.) Greene, Western Poison Ivy	0.16	3
<i>Cypripedium parviflorum</i> Salisb. var. <i>pubescens</i> (Willd.) Knight, Lesser Yellow Lady's-Slipper	0.16	4
<i>Solidago juncea</i> Ait., Early Goldenrod	0.13	3
<i>Hieracium piloselloides</i> Vill., Tall Hawkweed +	0.13	2
<i>Achillea millefolium</i> L. var. <i>millefolium</i> , Common Yarrow	0.13	2
<i>Linaria vulgaris</i> P. Mill., Greater Toadflax +	0.10	3
<i>Hypericum perforatum</i> L., Common St. John's-Wort +	0.10	2
<i>Clinopodium vulgare</i> L., Wild Basil	0.10	2
<i>Chimaphila umbellata</i> (L.) W. Bart. ssp. <i>cisatlantica</i> (Blake) Hultén, Pipsissewa	0.10	4
<i>Amelanchier alnifolia</i> (Nutt.) Nutt. ex M. Roemer var. <i>compacta</i> (Nielsen) McKay, Saskatoon **	0.10	3
<i>Viola nephrophylla</i> Greene, Northern Bog Violet	0.06	3
<i>Packera</i> ( <i>Senecio</i> ) <i>paupercula</i> (Michx.) A. & D. Löve, Balsam Groundsel	0.06	2
<i>Epipactis helleborine</i> (L.) Crantz, Helleborine +	0.06	2
<i>Solidago nemoralis</i> Ait. var. <i>nemoralis</i> , Gray Goldenrod	0.03	2
<i>Populus tremuloides</i> Michx., Quaking Aspen	0.03	2
<i>Lonicera tatarica</i> L., Common Honeysuckle +	0.03	2
<i>Antennaria</i> sp. (cf. <i>neglecta</i> ), Pussytoes	0.03	2
Total	120.22	

<sup>1</sup>Mostly *Pleurozium schreberi* and *Dicranum polysetum*

*comium splendens* and *Dicranum polysetum* (Table 1). There was no obvious change in the vegetation following the fire in the adjacent area. Thirty-seven vascular plants were recorded in the understory, 30 of which were native. Only *Carex eburnea* and bryophytes were prominent. The total cover averaged 120.22 m<sup>2</sup> per quadrat. The seven introduced species represented 0.66% of the total cover.

All vegetation in the burned site, including trees, had been killed by the fire. Nine years after the fire, the burned area had developed into a long-lasting succes-

sional shrubland dominated by shrubs, such as *Prunus virginiana*, *Arctostaphylos uva-ursi*, *Amelanchier alnifolia* var. *compacta*, and *Symphoricarpos albus*, and herbs, such as *Danthonia spicata* and *Carex richardsonii* (Table 2). Seventy-four vascular plants were recorded in the burned site, 11 of which were introduced, leaving 63 native. The total cover averaged 167.59 m<sup>2</sup> per quadrat. The introduced species accounted for 4.56% of the total cover.

The successional habitat that developed following a fire in boreal semi-open alvar woodland is thought



TABLE 2. Average cover and frequency values for plants less than 1 m tall in treeless burned alvar woodland 10 years after the fire. Tree cover was previously dominated by *Abies balsamea*, *Picea glauca*, *Pinus strobus*, *Populus tremuloides*, and *Thuja occidentalis*. The species are arranged in descending order of average percentage cover value, then by frequency, then alphabetically. The data are based on 30 quadrats 1 m<sup>2</sup> at least 2 m apart within an area of 4 ha. Species marked with two asterisks (\*\*) are regionally and/or provincially rare. Species marked with + are introduced. Species marked +? are possibly introduced.

Species	Average % cover	Frequency
<i>Danthonia spicata</i> (L.) Beauv. ex Roemer & J. A. Schultes, Poverty Wild Oat Grass	28.26	32
<i>Prunus virginiana</i> L., Choke Cherry	22.43	14
<i>Arctostaphylos uva-ursi</i> (L.) Spreng., Red Bearberry	18.13	19
<i>Amelanchier alnifolia</i> (Nutt.) Nutt. ex M. Roemer var. <i>compacta</i> (Nielsen) McKay, Saskatoon **	14.43	11
<i>Carex richardsonii</i> R. Br., Richardson's Sedge **	13.83	31
<i>Symphoricarpos albus</i> (L.) Blake, Common Snowberry	7.76	18
<i>Rosa acicularis</i> Lindl. ssp. <i>sayi</i> (Schwein.) W. H. Lewis, Prickly Rose	5.00	15
<i>Populus tremuloides</i> Michx., Quaking Aspen	5.00	6
<i>Toxicodendron (Rhus) rydbergii</i> (Small ex Rydb.) Greene, Western Poison Ivy	4.13	16
<i>Cornus sericea (stolonifera)</i> L. ssp. <i>sericea</i> , Redosier	3.63	8
<i>Solidago nemoralis</i> Ait. var. <i>nemoralis</i> , Gray Goldenrod	3.46	16
<i>Symphytotrichum (Aster) ciliolatum</i> (Lindl.) A. & D. Löve, Lindley's American-Aster	3.03	17
<i>Oligoneuron album</i> (S. asteroides, ptarmicoides) (Nutt.) Nesom, Prairie Flat-Top-Goldenrod	2.90	7
<i>Packera (Senecio) paupercula</i> (Michx.) A. & D. Löve, Balsam Groundsel	2.70	17
<i>Fragaria virginiana</i> Duchesne ssp. <i>virginiana</i> , Virginia Strawberry	2.43	15
<i>Hypericum perforatum</i> L., Common St. John's-Wort +	1.96	11
<i>Carex eburnea</i> Boott, Bristle-leaf Sedge	1.86	11
<i>Poa compressa</i> L., Flat-Stem Blue Grass +	1.86	6
<i>Bryum</i> sp., bryophyte	1.80	8
<i>Muhlenbergia glomerata</i> (Willd.) Trin., Spiked Muhly	1.73	9
<i>Pinus banksiana</i> Lamb., Jack Pine	1.66	3
<i>Solidago juncea</i> Ait., Early Goldenrod	1.36	12
<i>Hieracium piloselloides</i> Vill., Tall Hawkweed +	1.06	14
<i>Campanula rotundifolia</i> L., Bluebell	1.00	11
<i>Astragalus neglectus</i> (Torr. & Gray) Sheldon, Cooper's Milk-Vetch **	1.00	3
<i>Carex umbellata</i> Schkuhr ex Willd., Parasol Sedge	0.96	10
<i>Echium vulgare</i> L., Common Viper's-Bugloss +	0.96	5
<i>Viola adunca</i> Sm. var. <i>adunca</i> , Hook-Spur Violet **	0.76	8
<i>Penstemon hirsutus</i> (L.) Willd., Hairy Beardtongue	0.76	7
<i>Dichanthelium acuminatum</i> (Sw.) Gould & C. A. Clark var. <i>fasciculatum</i> (Torr.) Freckman, Tapered Rosette Grass	0.73	4
<i>Aquilegia canadensis</i> L., Red Columbine	0.63	6
<i>Juniperus communis</i> L. var. <i>depressa</i> Pursh, Common Juniper	0.60	5
<i>Trifolium hybridum</i> L., Alsike Clover +	0.56	8
<i>Medicago lupulina</i> L., Black Medick +	0.53	11
<i>Rubus idaeus</i> L. ssp. <i>strigosus</i> (Michx.) Focke, Common Red Raspberry	0.53	6
<i>Anemone cylindrica</i> Gray, Long-Head Thimbleweed	0.50	7
<i>Apocynum cannabinum</i> L., Indian-Hemp	0.50	3
<i>Calystegia spithamea</i> (L.) Pursh ssp. <i>spithamea</i> , Low False Bindweed **	0.46	7
<i>Polygala senega</i> L., Seneca-Snakeroot	0.43	5
<i>Solidago canadensis</i> L. var. <i>canadensis</i> , Canadian Goldenrod	0.40	4
<i>Lilium philadelphicum</i> L. var. <i>philadelphicum</i> , Wood Lily	0.40	4
<i>Taraxacum officinale</i> G. H. Weber ex Wiggers ssp. <i>officinale</i> , Common Dandelion +	0.33	6
<i>Cypripedium parviflorum</i> Salisb. var. <i>pubescens</i> (Willd.) Knight, Lesser Yellow Lady's-Slipper	0.33	5
<i>Sisyrinchium montanum</i> Greene var. <i>crebrum</i> Fern., Strict Blue-Eyed-Grass	0.33	3
<i>Waldsteinia fragarioides</i> (Michx.) Tratt. ssp. <i>fragarioides</i> , Appalachian Barren-Strawberry	0.26	4
<i>Euthamia graminifolia</i> (L.) Greene var. <i>graminifolia</i> , Flat-top Goldenrod	0.26	4
<i>Bromus kalmii</i> (Gray) Holub, Kalm's Brome **	0.26	4
<i>Panicum flexile</i> (Gattinger) Scribn., Wiry Panic Grass **	0.26	3
<i>Erigeron philadelphicus</i> L. var. <i>philadelphicus</i> , Philadelphia Fleabane	0.26	3
<i>Elymus trachycaulus</i> (Link) Gould ex Shinners ssp. <i>trachycaulus</i> , Slender Wild Rye	0.26	3
<i>Rosa blanda</i> Ait., Smooth Rose	0.23	5
<i>Isanthus brachiatus</i> (L.) B.S.P. ( <i>Trichostema brachiatum</i> ), False Pennyroyal	0.23	4
<i>Tragopogon dubius</i> Scop., Meadow Goat's-Beard +	0.23	3
<i>Scutellaria parvula</i> Michx. var. <i>parvula</i> , Small Skullcap	0.20	5
<i>Sporobolus vaginiflorus</i> (Torr. ex Gray) Wood var. <i>vaginiflorus</i> , Poverty Dropseed	0.20	4

TABLE 2. (continued)

Species	Average %	
	cover	Frequency
<i>Rhus aromatica</i> Ait. var. <i>aromatica</i> , Fragrant Sumac	0.20	4
<i>Rubus odoratus</i> L. var. <i>odoratus</i> , Purple-Flowering Raspberry	0.20	3
<i>Viola nephrophylla</i> Greene, Northern Bog Violet	0.16	4
<i>Rhus typhina</i> L., Stag-Horn Sumac	0.13	4
<i>Pteridium aquilinum</i> (L.) Kuhn var. <i>latiusculum</i> (Desv.) Underwood ex Heller, Bracken Fern	0.13	4
<i>Prunella vulgaris</i> L. ssp. <i>vulgaris</i> , Common Selfheal	0.13	3
<i>Diervilla lonicera</i> P. Mill., Northern Bush-Honeysuckle	0.13	3
<i>Potentilla norvegica</i> L. ssp. <i>monspeliensis</i> (L.) Aschers. & Graebn., Norwegian Cinquefoil +?	0.13	1
<i>Dichanthelium linearifolium</i> (Scribn. & Nash) Gould, Slim-Leaf Rosette Grass	0.10	3
<i>Arenaria serpyllifolia</i> L., Thyme-Leaf Sandwort +	0.10	3
<i>Eurybia</i> (Aster) <i>macrophylla</i> (L.) Cass., Large-Leaf Wood-Aster	0.06	4
<i>Arabis hirsuta</i> (L.) Scop. var. <i>pyncocarpa</i> (M. Hopkins) Rollins, Hairy Rockcress **	0.06	4
<i>Veronica peregrina</i> L. ssp. <i>xalapensis</i> (Kunth) Pennell, Neckweed	0.06	3
<i>Verbascum thapsus</i> L., Great Mullein +	0.03	3
<i>Silene antirrhina</i> L., Sleepy Catchfly	0.03	3
<i>Hedeoma hispida</i> Pursh, Rough False Pennyroyal	0.03	3
<i>Geranium bicknellii</i> Britt., Northern Crane's-Bill	0.03	3
<i>Clinopodium vulgare</i> L., Wild Basil	0.03	3
<i>Cirsium discolor</i> (Muhl. ex Willd.) Spreng., Field Thistle **	0.03	3
<i>Cirsium vulgare</i> (Savi) Ten., Bull Thistle +	0.03	3
<i>Agrostis hyemalis</i> (Walt.) B.S.P., Winter Bent	0.03	3
Total	167.59	

to be relatively long-lasting, since trees were observed to be invading slowly nine years after the fire and their establishment would only be possible following successful competition with a well-established shrubland flora. In the woodland, young trees represented 2.01% of the total cover, but in the burned woodland, after nine years, young trees represented only 3.97%.

The two sites had only 16.33% of species in common, and these common species accounted for only 24.77% of the combined cover of both sites. Consequently, the vegetation was >75% different with respect to biomass. There were nine regionally rare species in the burned area with a cover value of 31.09%. Only two regionally rare species, with a cover value of 2.85% were present in the unburned woodland.

Not only were there almost twice as many species in the burned site as well as higher frequency and cover values, but the values for all biodiversity indices and an evenness measure were also higher for the burned area (Table 3). Introduced species contributed to overall biodiversity, but they were a minor component at both sites, resulting in only slightly higher values than for native species alone.

## Discussion

The development of successional plant communities on alvar landscapes is likely to promote vascular plant biodiversity, which is often highest in mid-successional stages. The post-fire succession on alvars is unique and has high vascular plant biodiversity, so including fire, or an alternative biomass removal method, in the

management plan for portions of an alvar landscape is appropriate, if not essential. With the decline of ecological processes such as natural fire, it is to be anticipated that certain kinds of successional communities will be lost. Without dedicated management of protected areas, there will be declines in biodiversity. However, taking into account the extent to which fires occurred on alvars (Jones and Reschke 2005), the occurrence of unique species in alvar woodlands (personal observation), and the susceptibility of some species to fire (Siemann et al. 1996), only portions of alvar landscapes should be burned at any particular time.

Important considerations for fire management include the following: (1) maximum successional changes occur in early stages (Catling et al. 1999, 2001, 2002); (2) succession proceeds at different rates in different places; (3) the pre-settlement fire return interval on Great Lakes alvar landscapes was at least 200–500 years (Jones and Reschke 2005); and (4) there may be little change in many alvar woodlands more than 100 years old due to the maintenance by drought of early successional forest dominated by conifers. These considerations suggest that an alvar landscape with maximum biodiversity would include alvar woodlands burned 10, 30, 60, 100, and 200 years previously. After 100 years of management, the first burned area may have returned to alvar woodland. Of course, there are many considerations, such as maintaining sufficiently large wooded areas for forest-nesting birds, and adjustments to speed up the burn cycle may be necessary during the management period. Although the management



TABLE 3. Biodiversity measures for all species/native species in burned and unburned alvar woodland.

Biodiversity measure	Alvar woodland	
	Burned	Unburned
Number of species	76/65	39/32
Total cover	167.59/159.94	120.22/119.4
Total frequency	553/540	254/236
Simpson Index reciprocal (cover)	12.51/11.44	4.04/3.98
Simpson Index reciprocal (frequency)	45.39/37.76	20.09/17.61
Shannon-Wiener function (cover)	4.43/4.23	2.77/2.71
Shannon-Wiener function (frequency)	5.87/5.62	4.77/4.52
Brillouin's Index (frequency)	5.52/5.28	4.41/4.20
Smith-Wilson evenness (cover)	0.21/0.20	0.18/0.17
Smith-Wilson evenness (frequency)	0.73/0.72	0.66/0.65

of alvars with fire is complex, failure to attempt it is failure to simulate a natural process that preserves biodiversity.

Future studies of biodiversity and its relation to succession on alvar landscapes are needed to determine the extent to which diversity of various animal groups corresponds to that for vascular plants. This would also help to improve the general understanding of the effectiveness of easily surveyed plants in predicting biodiversity of animals which has a number of constraints (Wolters et al. 2006).

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# Habitat-Distribution Modeling of a Recolonizing Black Bear, *Ursus americanus*, Population in the Trans-Pecos Region of Texas

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Black Bears (*Ursus americanus*) were once widespread across Texas, but their numbers were reduced in the early 1900s. Recolonization of the Trans-Pecos region of Texas has occurred via bears migrating northward from Mexico. Recent bear sightings have increased in this area. This could be an indication that the population in Texas is beginning to recover, but the population will continue to expand only if there is suitable habitat to occupy. To help identify suitable habitat and restoration areas, we developed a predictive habitat-distribution model by using records of Black Bear sightings from 1996 to 2003 to map the species' distribution. Using Bayesian statistics, we modeled the probability of occurrence of Black Bears in the Trans-Pecos region based on sighting locations. We used GIS layers for land use/landcover, elevation, water sources, and road networks to obtain covariates in our modeling. We used a 10-fold cross-validation to test the effectiveness of using sighting data. Our results indicated a negative association with bare areas, agriculture, and grassland landcovers. In addition, southern aspect, elevation, distance to water, slope, and western aspect also influenced suitable habitat. Both the original and validation datasets correctly classified bear sightings 93.9% and 93.7% of the time, respectively. Our model can be used to target restoration efforts to enhance the ability of the Black Bear to expand in the Trans-Pecos region. It can also identify private landowners most likely to be affected by the expansion of Black Bears for education and cooperative efforts.

Key Words: Black Bear, *Ursus americanus*, Bayesian statistics, GIS, habitat prediction map, restoration, Trans-Pecos, Texas.

Black Bears (*Ursus americanus*) were reportedly widespread across Texas in the 1800s, but by the early 1900s their numbers had been reduced by overhunting, predator control, and loss of habitat (Onorato and Hellgren 2001; Whittaker and Burns 2001). By 1960, no Black Bears remained in Texas. In the early 1980s, a small bear population in northern Mexico served as a source population for natural recolonization of the Trans-Pecos region, and in 1987 Texas declared the Black Bear endangered (Onorato et al. 2003). There are now repeated sightings of Black Bear in the Dead Horse, Glass, Del Norte, Davis, and Guadalupe mountains, suggesting that bears may continue to expand their distribution into other parts of the Trans-Pecos (Figure 1; Onorato et al. 2003). The population size in Texas increased in the 1990s to an estimated 30–50 individuals, which resulted in a status change to threatened in 1996 (Whittaker and Burns 2001).

Four factors have likely contributed to the expansion of Black Bears in this region: (1) increased tolerance by humans of Black Bears, (2) legal protection of bears, (3) the existence of unoccupied woodland in Texas, and (4) the presence of a source population in Mexico (Onorato and Hellgren 2001; Kamler et al. 2003). Although research has been conducted on this population in Mexico and in Big Bend National Park, Texas (Doan-Crider 1995; Mitchell et al. 2002), there

has been no regional analysis of potential suitable habitat for expansion. Knowledge of the extent, spatial arrangement, and connectivity of suitable habitat is required to allow the possible colonization of unoccupied habitat to be predicted (Schadt et al. 2002). This is the first step in a regional restoration effort of a formerly extirpated Black Bear population.

Ecological restoration can occur within the context of regional landscape-level planning and design (Harris et al. 2001). One way to accomplish this is to build a model from environmental data and known locations of a focal species to predict the distribution of suitable habitat for the species (Guisan and Zimmermann 2000). Where data on population distribution and abundance are unavailable, detailed sighting information can be especially useful. Much of the information on Black Bears in the Trans-Pecos is available via conversations with locals (Onorato and Hellgren 2001) or sighting data collected by Texas Parks and Wildlife. The data include radiolocations, road kills, observations by biologists, and some reports made by members of the public. Sighting data have been used successfully to model habitat suitability for Lynx [*Lynx canadensis*] (Palma et al. 1999), Grizzly Bear [*Ursus arctos horribilis*] (Agee and Stitt 1989), Bobcat [*Lynx rufus*] (Woolf et al. 2002), and Mountain Lion [*Puma concolor*] (Pike et al. 1999).



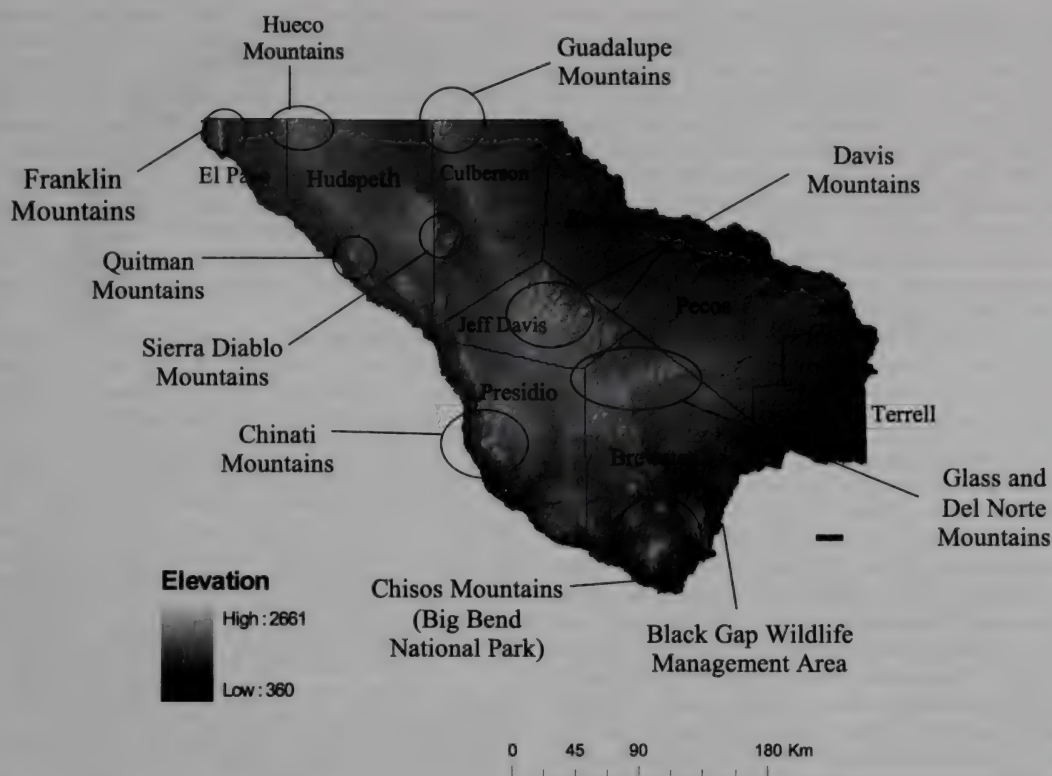


FIGURE 1. Map of the nine counties in the Trans-Pecos region of Texas with identified mountains ranges.

Although there are few cases of large carnivores naturally recolonizing an area, recolonization by Wolves [*Canis lupus*] in North America and Europe, by Brown Bears [*Ursus arctos arctos*] in Scandinavia, and by Black Bears in Oklahoma (Bales et al. 2005) indicates that the right conditions can exist. To understand whether an area can support increasing populations of vertebrates, it is imperative to understand the suitability of an area as habitat for a species (Queheillalt and Morrison 2006). Our objective for this study was to identify the potential expansion range of the Black Bear in the Trans-Pecos region based on potential habitat suitability. This will be a first step in providing wildlife managers with a comprehensive analysis of available Black Bear habitat to use in the development of a Black Bear management plan in western Texas.

## Methods

### Study Area

Due to its proximity to Black Bear habitat in Mexico and possibly New Mexico (Onorato et al. 2004), the 7.7 million ha Trans-Pecos region of Texas represents a large tract of potentially suitable habitat for bear

recolonization. The region is made up of nine counties in Texas and constitutes about 11% of the state. The environment in the Trans-Pecos is unique compared to other Black Bear habitat across the United States, since the lower elevations are part of the Chihuahuan Desert, the largest desert in North America (Powell 1998). This community is characterized by leaf succulent and semi-succulent plants that typically grow on exposed mountainsides and canyon walls (Gehlbach 1981). The area receives 30.5 to 45.7 cm of rain per year (Casey 1972; Steele 1998), and almost all the plants in the area have adaptations to conserve water. The mountains of the Trans-Pecos create a series of island woodland habitats (considered typical habitat for Black Bears) separated by sometimes inhospitable desert vegetation (Powell 1998). Elevations range from 2000 feet along the Rio Grande to more than 7000 feet in the high Chisos Mountains (Steele 1998).

### Sighting Data

We gathered sighting data dating from 1903 to 2003 from Big Bend National Park, Guadalupe Mountain National Park, and the Texas Parks and Wildlife Department. There were a total of 3675 sightings from all nine counties of the Trans-Pecos region (Figure 1). All sight-

ings were rated as class 1 or class 2 sightings, which indicate that a bear is in possession, there is tangible evidence documented, or it has been reported by an experienced and reliable witness. To account for the potential lack of independence in the data, we eliminated all sightings that occurred within the same month of the same year within a 5 km radius of any other sighting. We used sightings from only 1996 to 2003 for model development because we assumed that the landscape had changed over the past century and we wanted to use the most current data to model the near-term future expansion of the population. In addition, the data used to build the GIS environmental layers came from information gathered from 1997 to 2002, so our intent was to match the GIS database to the sighting data.

#### *Landcover Variables*

We selected potential covariates based on previous studies of Black Bears in New Mexico, Texas, and Mexico. Steep slopes, rock, and higher elevations were common settings for den placement by Black Bears in Big Bend National Park, so we included these three covariates (Mitchell et al. 2005). Disturbed areas such as roads and urban areas (mostly because of the attraction provided by trash) were important in Texas, so we included distance to roads, cropland, and urban habitats to account for these disturbed areas (Hellgren et al. 1991; Onorato et al. 2003). Two studies in other jurisdictions found that bears favored areas near water, so we included distance to water sources in our model (Garshelis and Pelton 1981; LeCount and Yarchin 1990). Woodland and sotol (*Dasyllirion wheeleri*) shrublands were found to be important landcovers for resource and food selection by Black Bears in this region (Hellgren 1993), so we included the availability of these landcover types as candidate variables.

We initially considered 15 variables for the model: elevation, aspect (south, west, north, and east), slope, distance to water, distance to roads, proportion of bare ground, proportion in agriculture, proportion of shrubland, proportion of grassland, proportion of wetland, proportion of woodland, and proportion of urban. Due to the lack of buffers containing wetland for both bear and random locations, we withheld the proportion of wetland variable from the model (Boccardi et al. 2008; Ciarniello et al. 2007).

We applied a 2.2 km radius around each bear record based on the average daily linear movement of female Black Bears from previous analyses (Fleckse et al. 2003; Rice 2006). The average daily movement of females has been used in other studies of large carnivores to buffer a point location (Carroll and Miquelle 2006). An equal number of random sightings was obtained using Hawth's tools in ArcGIS 9.0 (Beyer 2004\*), and these were considered "absence" sighting points ( $n = 2079$ ). Pseudo-absences are meant to provide a comparative data set to enable the conditions under which a species occurs to be contrasted to where

it is absent (VanDerWal et al. 2009). Based on findings that woodland is a significant predictor of bear habitat in this region (Onorato et al. 2003; Mitchell et al. 2005) and that 65% of our bear locations were located in the woodland landcover, we restricted the pseudo-absence point locations to woodland landcover (Poirazidis et al. 2004). Therefore, the proportion of woodland variable was not included in the model. The same 2.2 km buffer was applied to the pseudo-absence points, but we did not allow any overlap between bear sighting buffers and the pseudo-absence buffers (Poirazidis et al. 2004).

We derived environmental variables used in the model from relevant GIS layers. We obtained elevation data from the National Elevation Dataset from the U.S. Geological Survey for the elevation layer (resolution = 30 m). We then derived the slope and aspect layers using the Spatial Analyst extension in ArcGIS. We generated the landcover/land use layer from 10 Landsat images using ERDAS software that classified seven landcover/land use values (resolution = 30 m; Rice 2006). This layer was ground truthed and found to be 75% accurate (Rice et al. 2008). We used the National Hydrography Dataset to generate hydrology layers and determined the distance from each sighting and random point to the nearest water source. We obtained road data from the Texas Department of Transportation and calculated the distance from each sighting and random point to the closest road.

#### *Statistical Analysis*

We summarized all pixel values for each variable in each bear location buffer using the average and we repeated this process for the random sighting buffers. These variables were then centered by subtracting the mean for all buffers from each individual buffer to improve the efficiency of the Markov chain Monte Carlo algorithm by generating posterior samples with lower autocorrelation (McCarthy 2007). We used a generalized linear regression in the Bayesian framework using WinBUGS (Version 1.4; Spiegelhalter et al. 2003\*). The Bayesian approach incorporates prior knowledge and provides an interval within which the parameter value lies (O'Neill et al. 1988). We assumed no pre-existing knowledge of model coefficients. This resulted in the use of non-informative prior distributions for all variables (O'Neill et al. 1988; MacNally et al. 2004), meaning that our data dictate the posterior probability distributions (MacNally et al. 2004). Non-informative priors also reduce the risk of choosing a subjective distribution and make all parameters equally likely (Wintle et al. 2003). WinBUGS takes samples from the posterior distribution by using a Markov chain Monte Carlo sample (McCarthy 2007). We used three chains, each with a burn-in period of 1000 iterations followed by 50 000 iterations for estimation. An assumption of Bayes theorem is that predictor variables must be independent (Tucker et al. 1997). Therefore, we calculated correlations and if the



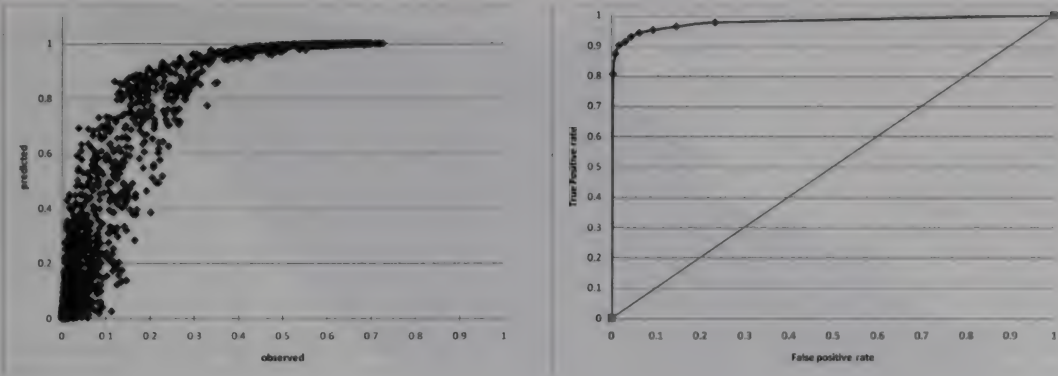


FIGURE 2. Validation procedures: (a) predicted values from the top model beta coefficients compared to the observed values from the original Black Bear locations; and (b) area under the receiver operating characteristic (ROC) curve, plotting sensitivity (true positives) vs. 1-specificity (false positives) for bear location predictions based on 10 threshold values from 0 to 1 in the Trans-Pecos region of Texas.

correlation was > 0.6 we removed those variables, which were deemed less important. This resulted in the removal of proportion of urban, proportion of shrubland, north aspect, and east aspect, resulting in 9 candidate variables for modeling.

We tested 10 models based on variable combinations found to be influential in previous studies. We chose the best model based on the deviance information criterion (DIC), the Bayesian equivalent of the Akaike Information Criterion (McCarthy 2007). The top model was the one with the lowest DIC score. We entered the resulting equation into ArcGIS using the raster calculator. We used the exponential function in the raster calculator of ArcGIS to calculate the following logit function:

$$\frac{e^{(\beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki})}}{1 + e^{(\beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki})}}$$

where  $\beta$  = parameter estimates,  $X$  = explanatory variables, and  $k$  = number of variables. This resulted in a probability layer with values ranging from 0 to 1. The probability of suitable bear habitat was assessed by comparing the predicted and the observed probabilities to determine an appropriate cut-off threshold.

We used a variety of validation procedures, as we did not have an independent data set to use for comparison purposes. For the top model, we evaluated the classification rates using Cohen's kappa at both the standard (0.5) and optimal probability (determined from Figure 2) cut-off points (Slauson et al. 2007). The Cohen's kappa statistic measures the proportion of bear locations and random locations predicted correctly after accounting for chance. We then evaluated the area

under the receiver operating characteristic (ROC), which provides a single measure of overall accuracy not dependent on a particular threshold (Graf et al. 2007). We plotted sensitivity (the probability that a model correctly classifies bear locations) versus 1-specificity (the probability that a model will incorrectly classify random locations) over a range of probability thresholds from 0 to 1 (Lantz et al. 2007).

Finally, we assessed the predictive capability of the top model based on a 10-fold cross-validation procedure (Boyce et al. 2002). We estimated the Bayesian model using a random draw of 90% of the data and used this model to predict the frequency of occurrence in the withheld 10% (Ciarniello et al. 2007). We used a Spearman rank correlation to assess the relationship between predicted occurrence for the withheld locations and their frequency within 10 equally sized classes of values from 0 to 1 (Johnson et al. 2005). To account for variation in the area covered by each category of resource selection function (RSF) bin on the landscape, we used an area adjusted frequency by dividing the 10 bins by the area covered by that range of scores (Boyce et al. 2002). A model with a higher  $R^2$  value is considered to be a good predictor (Long et al. 2009).

### Results

The elimination of multiple sightings resulted in a total of 3177 sightings overall and 2079 sightings from 1996 to 2003 for model development. The best fitting model (smallest DIC value) consisted of the full model with all variables included (Table 1). The second best model did not include the southern or western aspects, but it was not a real competitor with the top model (Table 1).

The top model indicated that bear sightings were negatively associated with bare landcover, agriculture, grassland, elevation, the southern aspect, and distance

TABLE 1. Ranking results for models of habitat suitable for Black Bears developed in the Trans-Pecos region of Texas.

Model <sup>1</sup>	Mean deviance	Deviance information criterion	pD <sup>2</sup>
a · g · b · e · sl · st · w · rdd · wtd	1351.085	1360.883	9.798
a · g · b · e · sl · rdd · wtd	1378.919	1386.767	7.848
a · g · b · e · st · rdd · wtd	1680.391	1688.365	7.974
a · g · b · rdd · wtd	1684.494	1690.404	5.91
a · g · b · e · rdd · wtd	1685.521	1692.444	6.923
a · g · b · e · st · wtd	1798.997	1805.963	6.966
a · b · e · sl · st	1842.076	1847.801	5.725
a · g · b · e · st	1939.222	1945.141	5.919
a · g · b	1945.761	1949.682	3.921
a · b · e · st	3359.408	3364.387	4.979

<sup>1</sup>a = agriculture g = grassland b = bare e = elevation sl = slope st = south aspect w = west aspect rdd = distance to roads wtd = distance to water  
<sup>2</sup>pD is the effective number of variables in the model

TABLE 2. Estimated posterior distribution coefficients for the top model based on Bayesian estimation, standard deviation, and 95% credible intervals for habitat suitable for Black Bears in the Trans-Pecos region of Texas.

Parameter	Mean of posterior distribution	Standard deviation	95% credible interval
Proportion of bare	-18.2986	4.15	-27.5728 to -11.2425
Proportion in agriculture	-14.8459	3.757	-21.9755 to -7.5090
Proportion of grassland	-6.62253	0.4172	-7.4820 to -6.6090
Southern aspect	-3.56822	0.7074	-4.9444 to -2.2117
Elevation	-0.00245	3.518E-4	-0.0031 to -0.0019
Distance to water	-0.00109	1.591E-4	-0.0014 to -0.0008
Distance to roads	7.12E-05	8.36E-5	-8.65E-5 to 0.0002
Slope	0.133474	0.009943	0.1164 to 0.1506
Western aspect	1.307644	0.6151	0.1715 to 2.4579

to water (Table 2). Bear sightings were positively associated with slope, the western aspect, and distance to roads. So we would expect suitable habitat not to be located near bare landcover, agriculture, or grassland and to be at lower elevations and closer to water sources. We would also expect suitable habitat to be on steeper slopes and further from roads. Although distance to roads was included in the model, the 95% credible interval included the value of 0, which indicates little influence on bear locations (McCarthy 2007). All other variables were significant, as they did not include the value of 0 in their credible intervals. The three landcover types included in the model were the three highest-ranking variables in the model, with bare landcover having the greatest influence.

Based on the observed versus predicted values, a threshold of > 0.4 probability for suitable habitat prediction is reasonable (Figure 2a). Potentially suitable habitat was mostly located in the mountainous regions of the Trans-Pecos (Figure 3). Considering the entire Trans-Pecos region, a probability value of > 0.4 accounts for about 25% of the landscape that contains relatively suitable habitat. Highly suitable habitat with probability values > 0.9 accounts for about 8% of the Trans-Pecos region, mostly restricted to the woodland and mountainous areas.

Correct classification (probability cut-off = 0.4) averaged 93.9% and 93.7% for the original and cross-validation datasets, respectively (Table 3a). Cohen's kappa indicated good model performance at both probability cut-offs of 0.5 and 0.4 for the original and validation datasets, respectively (Table 3a). The area under the curve from the model ROC plot indicated that the model correctly distinguished between a bear location and a random location (Figure 2b). All Spearman rank coefficients indicated that all cross-validated datasets were good predictors of suitable bear habitat (Table 3b).

Discussion

Landcover/land use seems to be the driving influence for the predicted expansion of this Black Bear population. Bear locations were negatively associated with grassland, agricultural areas, and bare patches of landscape. This would reflect the life history of bears and their ties to shrubland and woodland mast crops. In addition, the agricultural areas in this region are limited and are mostly associated with cattle ranches rather than food crops (Onorato et al. 2003).

Currently, the breeding population of Black Bears is located in the 372 377 ha of Big Bend National Park and Black Gap Wildlife Management Area. There



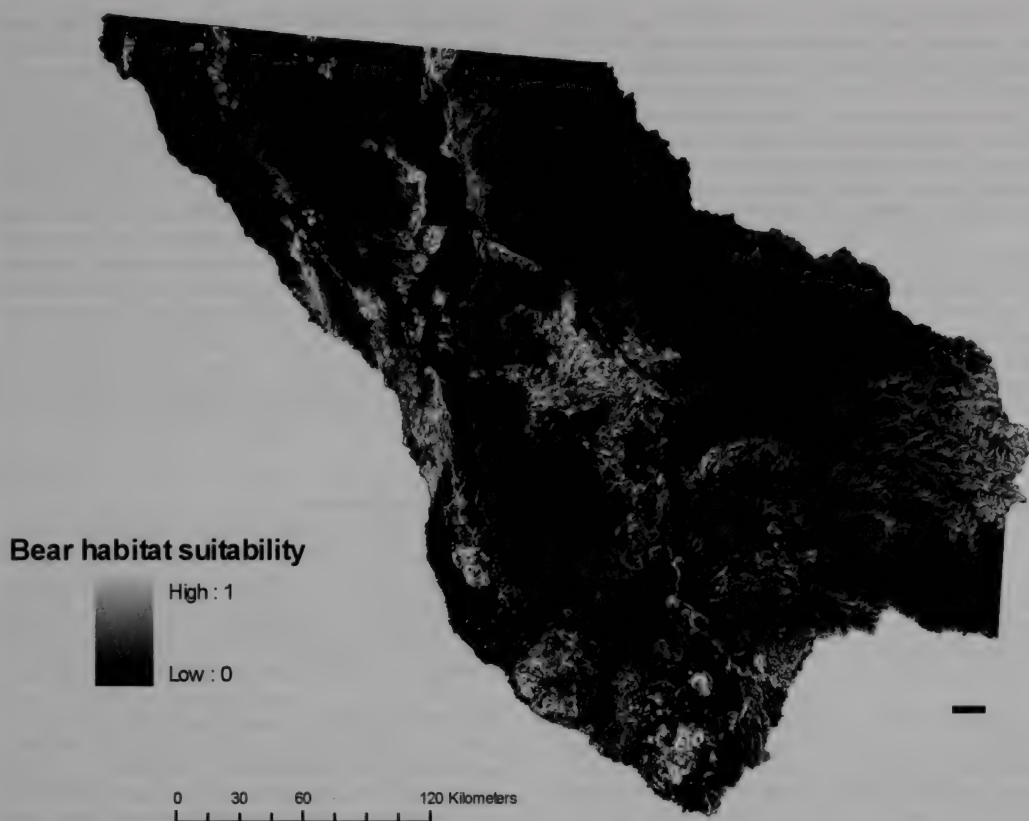


FIGURE 3. A. Comparison of measures for the original model dataset and the cross-validated datasets based on percentage correctly classified, sensitivity, specificity, Cohen's kappa at a threshold of 0.5, Cohen's kappa at a threshold of 0.4, and the area under the receiver operating characteristic (ROC) curve. B. Spearman rank correlations ( $r_s$ ) between resource selection function (RSF) bin ranks and area-adjusted frequencies for each cross-validated model set.

is a continuous strip of suitable habitat extending from Big Bend National Park and the Black Gap Wildlife Management Area to other suitable habitat patches in the Glass and Del Norte mountains, and this strip may serve as a corridor (Figure 1). The distances from Big Bend National Park to the next two patches of highly suitable habitat are 136.5 km to the Rio Grande and the Chinati Mountains in Presidio County and 188.1 km to the Davis Mountains in Jeff Davis County (Figure 1). These are feasible dispersal distances for this population, given that previous studies in the Trans-Pecos found that two females and one male traveled 154, 214, and 178 km, respectively (Hellgren et al. 2005). In addition, this region has a relatively low human population and little development threatening the region's habitats (Onorato et al. 2004). There is also a large percentage of predicted habitat in Hudspeth County in the northern Trans-Pecos region, so Black Bears may be able to expand south from the New Mexico region and Arapahoe National Forest.

Although sighting data have been used in many studies, there is still a stigma attached to such data. How useful are they? Often there is a strong locational bias, with higher sampling rates in the most accessible sites (Davis et al. 1990). There can also be an issue when only a few individuals exist in a population, because this limits the number of independent sightings and lowers the power of statistical inferences (Stoms et al. 1993). Although using sighting data to develop a model of potential habitat has its disadvantages, our validation procedures indicated our model is robust. In addition, the effort and cost involved in a mark-recapture or hair-capture study are too high for a region this large. Sighting data provide a useful dataset for investigating the general patterns of a small population across a large region such as the Black Bear in the Trans-Pecos.

Some of the potential habitat lies along the banks of the Rio Grande, which forms the western boundary of the Trans-Pecos in Texas. Riparian areas interspersed with other cover types have been found to be impor-

TABLE 3. A. Comparison of measures for the original model dataset and the cross-validated datasets based on percentage correctly classified, sensitivity, specificity, Cohen's kappa at a threshold of 0.5, Cohen's kappa at a threshold of 0.4, and the area under the receiver operating characteristic (ROC) curve. B. Spearman rank correlations ( $r_s$ ) between resource selection function (RSF) bin ranks and area-adjusted frequencies for each cross-validated model set.

A.		
Measure	Original	Validation
Correct classification (%)	93.9	93.7
Sensitivity	0.925	0.924
Specificity	0.836	0.835
Cohen's kappa (0.5 threshold)	0.885	0.881
Cohen's kappa (0.4 threshold)	0.879	0.875
Area under the curve (AUC)	0.977	0.975

B.		
Set	$r_s$	
1	0.923	
2	0.939	
3	0.927	
4	0.964	
5	0.939	
6	0.903	
7	0.976	
8	0.915	
9	0.988	
10	0.964	
Combined	0.891	

tant in other regions (Koehler and Pierce 2003) and may be essential in the desert environment of Mexico and Texas. Our study indicated that Black Bear locations were closer to water sources than random locations, and this could indicate that Black Bears are relying on water resources in this region. With less than 1% of the original riparian vegetation in the western United States remaining (Queheillalt and Morrison 2006), wildlife managers should consider restoring important water resources within the predicted Black Bear habitat in the Trans-Pecos in cooperation with private landowners. This would provide routes to enable Black Bear expansion if it were to continue into the predicted areas.

The Black Bear has been described as an umbrella species, flagship species, and habitat quality indicator (Dugelby et al. 2001). Maintaining habitat for Black Bears can presumably preserve most other species in the same habitat (Davis et al. 1990). Although restoration usually entails the enhancement or alteration of the environment, the natural recolonization by Black Bears of the Trans-Pecos could provide a different scenario. The normal factors limiting the re-establishment of a population, such as habitat loss, habitat fragmentation, and anthropogenic constraints, are largely absent in this region (Sanderson et al. 2008). Much of the potentially suitable habitat may be occupied by large

cattle ranges and privately owned land (Doan-Crider 1995) rather than highly populated urban centers. Perhaps the most effective option for the management of this Black Bear population is to preserve habitat in key suitable habitat areas in cooperation with private landowners. In addition, to increase the ability of Black Bears to reach suitable habitat, safe travel for Black Bears that may be dispersing would be essential to any restoration effort. Our prediction map can be used not only to identify potential expansion areas for Black Bears but also to provide managers with a tool for identifying landowners that could be most affected by bear colonization. The continued effort of habitat protection and cooperation with landowners will greatly benefit this small Black Bear population and perhaps enable the natural recolonization of the Trans-Pecos region.

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# Slender Moonwort, *Botrychium lineare* (Ophioglossaceae), Rediscovered in Quebec

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Cayouette, J., and Donald R. Farrar. 2009. Slender Moonwort, *Botrychium lineare* (Ophioglossaceae), rediscovered in Quebec. *Canadian Field-Naturalist* 123(3): 255–259.

Slender Moonwort (*Botrychium lineare*), described in 1994, is a very rare fern in eastern North America. It was known in Quebec, Canada, from only two sites in the Gaspé Peninsula but has not been relocated since its discovery at these sites in 1902 and 1942. An ongoing study of *B. lineare* and its recent discovery in northern Minnesota prompted a re-examination of a 1972 collection made in western Quebec, in Gatineau Park, previously identified under various names, including *B. campestre*. A recent visit (2008) to the Gatineau Park site disclosed continued presence of similar plants. Based on morphological characters, spore size, genotype (allozyme electrophoresis), and appropriate habitat features, we conclude that the newly discovered plants and those of the 1972 collection are *B. lineare*. *B. lineare* appears on the Quebec government list of plant species likely to be designated threatened or vulnerable.

**Key Words:** Slender Moonwort, *Botrychium lineare*, Prairie Moonwort, *Botrychium campestre*, Ophioglossaceae, spores, rare plants, Quebec.

Slender Moonwort (also called Narrowleaf Grape-fern), *Botrychium lineare* W.H. Wagner (Figure 1), was described in 1994 (Wagner and Wagner 1994) just one year after the publication of the moonwort family in Volume 2 of the *Flora of North America* (Wagner and Wagner 1993). The Wagners stated that they had begun to recognize the species as distinct about 1978 and finally gathered enough material and evidence to describe it. The species was initially considered to be very rare in North America. In addition to the type collection from Oregon, the species had been found in the United States in California, Idaho, and Montana, and in Canada in New Brunswick and Quebec (Wagner and Wagner 1994). The largest populations numbered 45 and 15 individuals, and a total of only 85 specimens had been seen by the Wagners at the time they described the species.

Today there is better knowledge of this little fern and its habitat, with the addition of substantial collections in western North America, including the Yukon Territory (Farrar 2006\*). Although some of the earliest known populations seem to have disappeared, DRF has observed perhaps 100 or more sites, some with hundreds of plants, between South Dakota and California and southern Nevada to Alaska and Yukon. On this basis, the US Fish and Wildlife Service removed Slender Moonwort from its list of Candidate Endangered Species.

However, the situation is very different in eastern North America, where it is one of the rarest species. Only five eastern populations have been recorded: two recently discovered sites in Minnesota and the three



FIGURE 1. *Botrychium lineare* (Mont Commis, Quebec, E. Lepage 3395, QFA 95938).

sites cited by the Wagners (one in New Brunswick and two in Quebec; Wagner and Wagner 1994). Attempts by Herb and Florence Wagner to relocate the population observed in 1904 in New Brunswick failed (Wagner and Wagner 1990\*).

In Quebec, the two previously located sites are in the Gaspé Peninsula, one at Paspébiac (Bonaventure County: Paspébiac Lighthouse, gravelly beach, 27 July 1902, *E.F. Williams & M.L. Fernald s.n.*, Gray Herbarium, Harvard University (GH)) and the other at Mont Commis, east of Rimouski (Rimouski County: St. Donat, Mont Commis, tablette herbeuse au pied de la muraille, 2 July 1942, *E. Lepage 3395*, Louis-Marie Herbarium, Université Laval (QFA) (Figure 1), Marie-Victorin Herbarium, Institut de recherche en biologie végétale and Université de Montréal (MT)). To our knowledge, the Paspébiac population has not been observed recently. However, serious attempts were made to examine the Mont Commis population. In July 1990, the Wagners, with the help of Pierre Morisset of Université Laval, Quebec City, his wife Catherine, and a colleague, and with guidance from the staff of the Louis-Marie Herbarium, found the site where Quebec botanist Ernest Lepage had discovered Slender Moonwort in 1942 (Figure 1) (Wagner and Wagner 1990\*). Climbing on various exposed ledges, the group carefully explored the north-facing limestone cliff at the top of a wooded talus. Despite considerable effort, they found only the Mingan Moonwort (*Botrychium minganense* Victorin), which had also been collected by Lepage along with the then unknown *B. lineare*. The Wagners attributed the failure to locate the population either to its extirpation or simply to the fact that it did not appear that year (Wagner and Wagner 1994).

In July 2000, JC, accompanied by botanists Frédéric Coursol, Martine Jean, and Jacques Labrecque, made another attempt to find *Botrychium lineare* at the Mont Commis site, but we were also unsuccessful. Given the lack of confirmed locations, the Slender Moonwort has been considered to be very rare in Quebec, with a ranking of SH (Possibly extirpated (historical)) (Labrecque and Lavoie 2002\*), and it was still similarly ranked in the most recent edition of the Quebec list of species likely to be designated threatened or vulnerable (CDPNQ 2008\*).

The claim that the species has been rediscovered in Quebec, based on a re-identified collection made in Gatineau Park in 1972 (Figure 2) and on a specimen collected in the same area in 2008 (Figure 5), requires justification. Moonwort classification and identification are very complex (Farrar 2006\*; unpublished data). Identifications based on undeveloped specimens are challenging even for specialists. Recent isozyme and molecular marker techniques are now very useful tools that are assisting in moonwort identification and taxonomy.

The 1972 collection in Gatineau Park (Quebec, Gatineau County: ½ mile east of the junction of Mountain

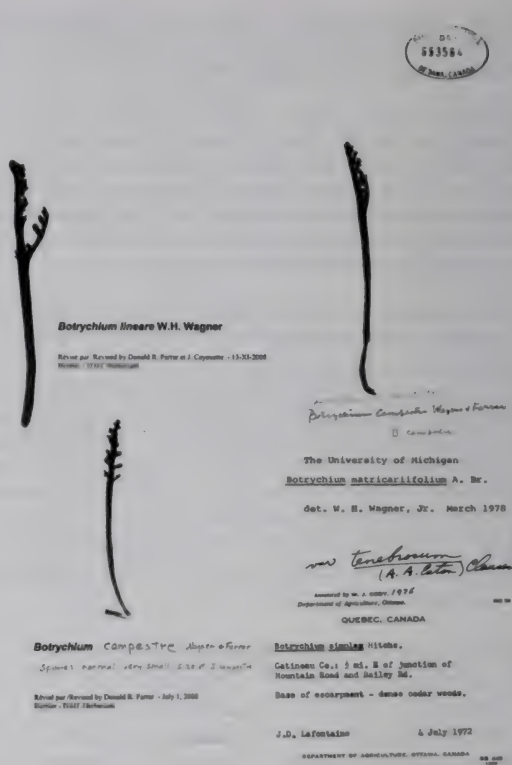


FIGURE 2. *Botrychium lineare* collected in 1972 in Gatineau Park, Quebec (J.D. Lafontaine s.n., DAO 653584).

Road and Bailey Road, base of escarpment, dense cedar woods, 4 July 1972, *J.D. Lafontaine s.n.*, DAO 653584) received four different identifications before it was finally determined to be *Botrychium lineare* (Figure 2). The specimens, at the early sporulating stage, were first identified as Least Moonwort (*Botrychium simplex* E. Hitchcock) and its variety *tenebrosus* (A.A. Eaton) Clausen. They were next identified as Daisy-leaved Moonwort (*B. matricariifolium* (Döll) A. Brown) preceding the recognition of the two following taxa. The collection was next identified as Prairie Moonwort (*B. campestre* W.H. Wagner & Farrar) by the two specialists who described that species as new (Wagner and Wagner 1986), and that identification was at first confirmed earlier in 2008 by DRF.

*Botrychium simplex* var. *tenebrosus* and *B. matricariifolium* superficially resemble *B. lineare*, but *B. campestre* is a closer relative (Wagner and Wagner 1994; Farrar 2006\*). *Botrychium simplex* var. *tenebrosus* differs from *B. lineare* by the trophophore (refers to the sterile lamina or blade of a botrychium leaf) having medial segments (pinnae) wider than long, mostly rhombic, ovate or elliptical, and frequently decurrent along the rachis, and by the length of the stalk (unbranched portion) of the sporophore (the sporangium-bearing half of a botrychium leaf) exceeding or nearly



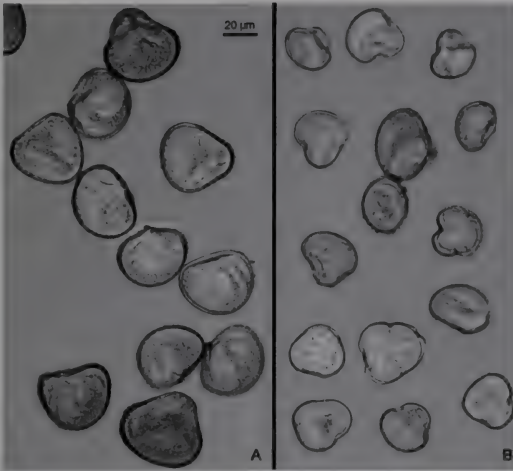


FIGURE 3. Spores of *Botrychium*: a) *B. cf. matricariifolium* (J. Cayouette C9614, DAO); b) *B. lineare* (J.D. Lafontaine s.n., DAO).

equal to the entire length of the trophophore. In *B. lineare*, the medial trophophore segments are longer than wide, mostly linear, not decurrent on the rachis, and the sporophore stalk is very short, only one-quarter to one-half the length of the trophophore (Figures 1, 5 and 6).

*Botrychium matricariifolium* differs from *B. lineare* by the trophophore segments above the proximal pair, ovate to elliptic, frequently strongly pinnately divided or at least clearly lobed (Figure 4), with pinnate nervation (the central one enlarged), by proximal pair not so different from the adjacent one (Figure 4), by a long sporophore stalk, and by relatively large spores (Figure 3a). On the other hand, *B. lineare* has the trophophore segments above the proximal pair, linear and sometimes palmately lobed or cleft toward the apex (Figures 1 and 6), with palmate nervation, a shorter sporophore stalk, and smaller spores (Figure 3b).

Slender Moonwort is a close relative of *Botrychium campestre*. They are both diploid species, rather short, with very short sporophore stalks, and with trophophore segments narrow, linear or spatulate, relatively undivided (or, if divided, palmately cleft into two to four segments) and frequently well spaced and separated (Farrar 2006\*).

The main differences are related to their morphology, ecology and phenology (Wagner and Wagner 1994; Farrar 2006\*). At the morphological level, the trophophore rachis of *Botrychium campestre* is fleshy and broad, up to one-third as wide as the whole trophophore, dull and whitish green, their segments linear to spatulate, commonly overlapping or fused, clearly enlarged at the apex, up to 3-5 lobed, the longest segments toward the upper portion of the trophophore; the entire sporophore length is 1.0–1.5 times that of



FIGURE 4. Shade specimens of *Botrychium matricariifolium* collected in the Ottawa National Forest, Gogebic County, Michigan, USA (D.R. Farrar, various numbers).

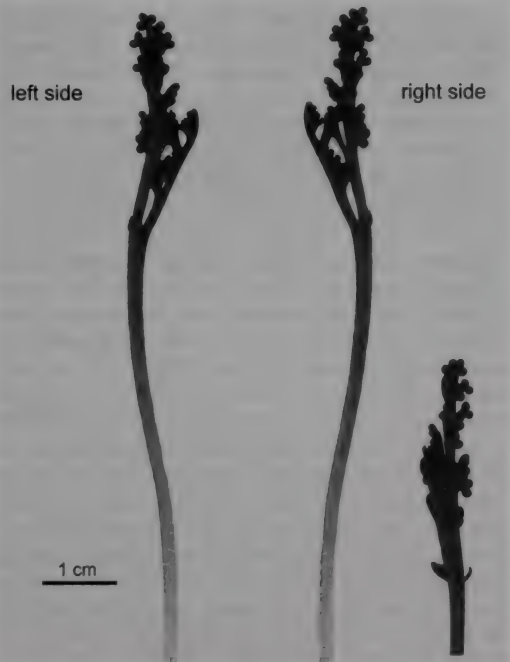


FIGURE 5. *Botrychium lineare*, same specimen viewed from different sides (Gatineau Park, Quebec, J. Cayouette C9615, DAO).

the trophophore. On the other hand, the trophophore rachis of *B. lineare* is more herbaceous and narrower, up to one-fifth as wide as the whole trophophore, pale green, their segments more linear or slightly spatulate, separated, slightly enlarged at the truncate apex, with the longest ones, located at the base of the trophophore, sometimes two or more times bifid; the sporophore is up to 2.0 times the trophophore in length. These differences are more easily observed in well-developed specimens.

*Botrychium campestre* is rather a prairie species of open habitat, where it is also frequently found under Ground Juniper bushes (*Juniperus communis* L. var. *depressa* Pursh) and even close to stands of Eastern Red Cedar (*J. virginiana* L.). This species appears very early. In Iowa, the trophophores are out in April and have disappeared in mid-June (Farrar 2006\*). Spores start to mature in May. By contrast, *B. lineare* has been found in various types of habitats, but in eastern North America it occurs in open forests (Wagner and Wagner 1990\*, 1994; Farrar 2006\*). It appears later, and spores mature from late June to July. Both species seem to prefer calcareous sites.

Based on the previous identification of the 1972 Gatineau Park specimen to *Botrychium campestre* (Figure 2) and on the presence of another collection so identified from the Mingan Islands area, this species was earlier included in the flora of Quebec and in a previous list of rare species (Labrecque and Lavoie 2002\*). However, due to recent revisions of the Mingan Islands specimens to Upswept Moonwort (*B. ascendens* W.H. Wagner)—the populations recently relocated and identification confirmed by Labrecque (2007\*)—and to the uncertainty of the Gatineau Park identification, *B. campestre* was removed from the flora of Quebec and as part of the rare plant list (CDP-NQ 2008\*). The current redetermination of the 1972 specimen to *B. lineare* confirms this decision.

At the end of June 2008, DRF examined the 1972 specimen in the Agriculture and Agri-Food Canada National Collection of Vascular Plants, Ottawa (DAO) (Figure 2), and found that the small size of the spores (Figure 3b) was consistent with the species being diploid, with the result that the name of *B. campestre* would be appropriate. On 1 July 2008, in an attempt to relocate the site in Gatineau Park, the authors found four small specimens of *Botrychium* with larger spores (Figure 3a), which better fit the *B. matricariifolium* group, and one plant that appeared to be *B. lineare*. The next day, JC found another site close by with a few more specimens, one of which appeared to be *B. lineare* (Figure 5). The sporophore is somewhat longer than the trophophore, and the trophophore segments are well spaced, narrow, linear, just slightly enlarged at the apex, and sometimes lobed. The above-ground leaf of the specimen (Quebec, Gatineau, Parc de la Gatineau, chemin de la Montagne, sous-bois de *Thuja occidentalis* sur rochers de marbre, au pied d'un

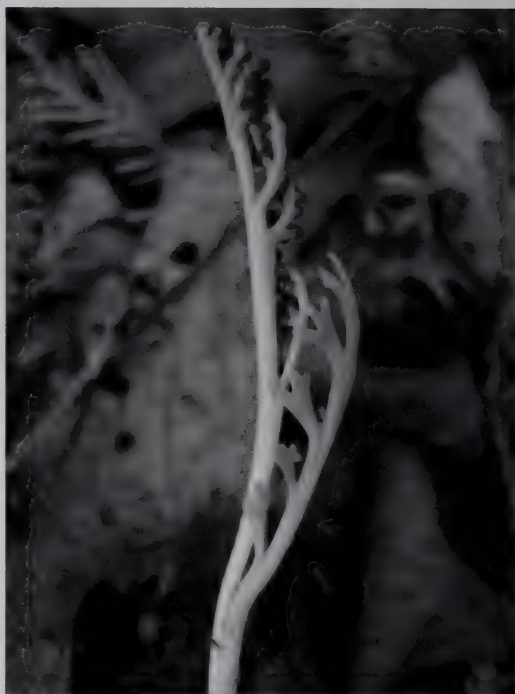


FIGURE 6. *Botrychium lineare* collected in 2009 in Gatineau Park, Quebec. Photo: J. Labrecque.

escarpement, 2 July 2008, J. Cayouette C9615, DAO) was sent to DRF for genotype analysis via enzyme electrophoresis. This analysis revealed the plant to be *B. lineare*. Owing to the failure to rediscover this rare species in the Gaspé Peninsula and in New Brunswick, the Gatineau specimen becomes the easternmost known extant population of this species in North America.

This site is situated at the base of the Eardley escarpment, where stands of White Cedars (*Thuja occidentalis* L.) indicate the presence of Precambrian marble. The plant diversity seems to be very limited where *Botrychium lineare* was found. Apart from White Cedars, only shrubs of Mountain Maple (*Acer spicatum* Lam.) and Red-Osier Dogwood (*Cornus sericea* L.) were observed, along with a few herbaceous plants such as Marginal Wood Fern (*Dryopteris marginalis* (L.) Gray), Woodland Strawberry (*Fragaria vesca* L.), and Rock Polypody (*Polypodium virginianum* L.).

The southern exposure of the habitats of the Eardley escarpment are conducive to the presence of some of the rarest plants of the Quebec flora. In 1971 and 1972, botanists Daniel Brunton and Donald Lafontaine made substantial discoveries of rare plants close to the site of *Botrychium lineare*, such as Sicklepod (*Boechera canadensis* (L.) Al-Shehbaz), Purple-Stem Cliff-Brake (*Pellaea atropurpurea* (L.) Link), and Blunt-Lobed Woodsia (*Woodsia obtusa* (Spreng.) Torrey) (Lafontaine



1973; Brunton and Lafontaine 1974). Later and still in the same area, Daniel Gagnon discovered the rare Eastern Few-fruited Sedge (*Carex oligocarpa* Willd.) (Hay and Gagnon 1986). Up to now, these are the only sites in Quebec for *Boechera canadensis* and *Carex oligocarpa* (CDPNQ 2008\*). This is now also the case for *Botrychium lineare*.

We hope the information presented here on *Botrychium lineare*, including its spore size, habitat preference for rocky calcareous sites, and phenology, will aid in the search for new sites of this extremely rare fern in eastern North America.

## Note

After the completion of this paper, additional information became available on the same Gatineau Park population of *Botrychium lineare*. In July 2009, an inventory of the site was conducted (Cayouette and Labrecque 2010\*). Forty-four individuals of *Botrychium lineare* (Figure 6) were discovered and their habitat evaluated. The *B. lineare* population was found to be slightly more widespread than expected. A few individuals of two other species of *Botrychium* were discovered on the site: *B. matricariifolium* (probable) and *B. minganense*. Further surveys are planned in order to follow the development of the population.

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## Notes

### Coyote, *Canis latrans*, Predation on a Bison, *Bison bison*, Calf in Yellowstone National Park

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Sheldon, J. W., Gregory Reed, A. Cheyenne Burnett, Kevin Li, and Robert L. Crabtree. 2009. Coyote, *Canis latrans*, predation on a Bison, *Bison bison*, calf in Yellowstone National Park. *Canadian Field-Naturalist* 123(3): 260–261.

We observed a single adult male Coyote (*Canis latrans*) kill a Bison (*Bison bison*) calf in Yellowstone National Park. The predation is, to our knowledge, the only direct and complete observation of a lone Coyote capturing and killing a Bison calf. The bison calf had unsuccessfully attempted to ford a river with a group and subsequently become stranded alone in the territory of a six-year-old alpha male Coyote.

**Key Words:** Coyote, *Canis latrans*, Bison, *Bison bison*, predation, Yellowstone.

In the Yellowstone ecosystem, Coyote spring/summer diet consists of small mammals and ungulate neonates, primarily American Elk calves (*Cervus elaphus*), but also Pronghorn (*Antilocapra americana*) calves and the fawns of Mule Deer (*Odocoileus hemionus*) and White-tailed Deer (*O. virginianus*) (Murie 1940; Gese and Grothe 1995; Gese et al. 1996). Bison (*Bison bison*) appear to be a rare food source for Coyotes. Murie's (1940) analysis of 5086 Coyote scats showed a percentage occurrence of 0.20% Bison, and Murie found it unlikely that Coyotes would kill Bison calves, recording that anecdotal reports of the same "lacked proof" (page 117). More recently, a study of Coyote predation on large ungulates in Yellowstone found that both White-tailed Deer and Elk were killed by packs of Coyotes hunting together in winter (Gese and Grothe 1995). No predation on Bison was recorded in either of these Yellowstone Coyote studies. Circumstantial evidence at kill sites in Yellowstone has suggested that predation on Bison calves by groups of Coyotes may occur, but no report has been published. A single instance of cooperative hunting by a Wolf (*Canis lupus*) accompanied by a pack of four Coyotes resulted in a Bison calf mortality (Smith et al. 2001). However, successful solo predation by a Coyote on a Bison has not, to our knowledge, been previously observed. An instance of predation on a calf after separation from the herd was observed in Elk Island National Park, Canada (Lu Carbyn, personal communication); however, a fence served to trap the calf. Our observation therefore extends what has been known about the predatory capacity of Coyotes with regard to large ungulates.

The observers (GR, ACB, and KL) arrived at a vantage point on the Lamar River, Yellowstone National

Park (44°54'48.774"N, 110°16'28.28"W) on 28 May 2009 at 1825 h. Yellowstone cinematographer Bob Landis reported (personal communication) that, at approximately 0700 h, a cow-calf herd of Bison swam the river from south to north, northeast of the observers' vantage point. During the crossing, a calf was washed 300–500 m downriver from the main group, emerging on the northern bank 100 m east of the vantage point. The Bison herd proceeded southward, leaving the calf behind on the opposite side of the river. By 1600 h, the Bison calf had bedded down west of the vantage point and the Coyote was present approximately 10 m from the calf. When GR, ACB, and KL arrived, the Coyote had already attacked the calf once, according to observers already present.

The Coyote, M361, was radio-tagged in October of 2004 (capture weight 13.2 kg) and had been monitored continuously since then. At the time of the event, he was the six-year-old alpha male of the Paradise Park pack, occupying a known home range which encompassed the kill site. The mean weight of Bison calf neonates is ~23 kg (Mattson 1997), thus the calf outweighed Coyote M361 by a factor of two.

The following observations were recorded on 28 May 2009:

1939 h M361 approached the bedded Bison calf from the rear and bit repeatedly at the hind legs. The calf stood up kicking, striking M361 in the head. This interaction lasted approximately 30 seconds, after which M361 moved to a position 10 m from the calf and bedded down. The calf remained standing.

2014 h The calf lay down approximately 10 m away from M361.

2132 h M361 stood up and attacked the calf. The calf stood up and kicked at M361 as he bit at the calf's back legs. M361 then bit the neck of the calf and pulled the calf to



the ground. The calf struggled for approximately two minutes as M361 continued to hold onto its neck.

2134 h The calf stopped moving. M361 lay down next to the calf.

2138 h M361 began feeding on the calf.

The predation sequence, which began before 1800 h, was concluded at 2134 h, an elapsed time of 3.5 hours. This "slow-motion" predation method has been observed in other ungulate encounters between Coyotes and Elk and White-tailed Deer: Gese and Grothe (1995) observed predation sequences by Coyotes lasting up to 21 hours. Prey may undergo physiological shock and/or become stiff during the extended interaction, providing a strategic advantage for the Coyotes. The extent to which shock/hypothermia resulting from the Bison calf's river crossing effort contributed to its vulnerability is unknown.

Coyotes are opportunistic predators capable of killing ungulate prey, usually hunting in packs. However, Bison embody a formidable set of anti-predator adaptations, including well-developed maternal guarding behaviors (Carbyn and Trottier 1987, 1988), general herd behaviors of cow-calf groups, and size constraints that regulate prey acquisition by the relatively small-framed and light-weight Coyote. The cost of predation attempts on ungulate neonates is demonstrably high: an alpha female Coyote with pups in the den was killed during a predation attempt on an Elk calf (unpublished data; this study; 2005), with her post-mortem indicating blunt-force trauma as the cause of death. Certainly, predation attempts on ungulate neonates are a high-risk activity for Coyotes. Notably, in eight out of nine predation attempts on large ungulate prey, the alpha male led the attack (Gese and Grothe 1995), as was also the case in our observation. In this instance, the stranding of the Bison calf was a causal factor leading to its death.

The observed successful kill by a single adult male Coyote shows that predation on Bison calves may be possible under certain, albeit rare, conditions involving separation of a calf from its mother. It also shows that the size/weight limit of prey for adult Coyotes may be revised slightly upward. The ecological context for the observed predation suggests that it may be part of a larger prey-switching phenomenon accompanying changes in spring use areas by ungulate prey, prima-

rily Elk (Garrott et al. 2007). Our observation is of additional interest because the Yellowstone ecological community embodies the southernmost outpost of an intact and functioning ungulate-predator system in North America, surrounded by areas of increasingly intensive human activity.

### Acknowledgments

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## Standing-Over in Captive Coywolves, *Canis latrans* × *lycaon*

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Way, Jonathan G. 2009. Standing-over in captive Coywolves, *Canis latrans* × *lycaon*. Canadian Field-Naturalist 123(3): 262–264.

I documented standing-over behavior in a captive Coywolf (*Canis latrans* × *lycaon*, Eastern Coyote) pack from April 2002 to October 2003. Standing-over involves an individual positioning its inguinal area over a recumbent (i.e., lying) individual's head. While all five Coywolves in my study pack performed standing-over, the dominant female was responsible for the vast majority. Thus, standing-over appears to be primarily female-oriented, as has previously been reported for Wolves, *Canis lupus*, and may involve two functions: (1) to advertise the reproductive state of the animal doing the standing-over and (2) to assert dominance via a low-intensity agonistic interaction.

**Key Words:** Coywolf, Eastern Coyote, *Canis latrans* × *lycaon*, agonistic/aggression, behavior, breeding/dominant female, standing-over.

To fully understand a given species' social system, it is important to gain insight into the nature of interactions between members of that species. Some animals, like Coywolves (*Canis latrans* × *lycaon*) (also called Eastern Coyote; Way et al. 2010), are elusive and are rarely observed for extended periods in the wild (although see Way 2003 and 2007a); therefore, it is likely that there are aspects of the behavior that have previously not been reported. Many of the constraints of observing Coywolves in the wild can be rectified by observing them in captivity (e.g., Way et al. 2006). Either in the field or in captivity, however, it is important to note behaviors which take place in a given species to see if they occur within closely related species. For instance, this could aid in identifying relatedness among and between taxa/species. For example, the Coywolf is a Coyote × Eastern/Red Wolf hybrid that currently has questionable taxonomic status (Way et al. 2010). Gaining insight into behaviors documented among closely related species of *Canis* could aid scientists/managers in properly classifying the species within their jurisdictions.

Standing-over has been documented in Wolves, *Canis lupus*, both in the wild (Mech 2001) and in captivity (Goodmann and Klinghammer 1990\*: 26; Schmidt et al. 2004\*: 51). Standing-over, as defined by Mech (2001), is a low-intensity display in which one canid casually approaches a recumbent (i.e., lying) one and stands over or alongside the recumbent canid so that the standing individual's groin is positioned above the recumbent canid's nose. It is not usually characterized by aggression or play. To my knowledge, this behavior has not been reported in Coyotes (*Canis latrans*) or Coywolves, either in the wild or in captivity, except briefly by Way et al. (2006: 270). This study describes unique behavioral data previously unreported.

### Methods

This study took place from April 2002 to October 2003 on five captive, hand-reared Coywolves detailed

previously (Way et al. 2006; Way 2007b). The pups were born on 18 and 19 March 2002, so were studied from the age of 1 month to 19 months. I created an ethogram on Coywolf behavior on standardized observation forms whereby I used focal animal sampling to collect spot/instantaneous fixes every 15 seconds for 30 minutes (Way et al. 2006). Typically one or two 30-minute observation bouts took place six days a week. Of the 540 behavioral patterns recorded on the ethogram, 6 of those described different positions of standing-over behaviors (see Way et al. 2006: 270).

To assess for dominance, I quantified dyadic interactions. I ranked the Coywolves and called the top-ranking male and female the dominant pack members. The remaining three Coywolves were referred to as intra-sex (i.e., male or female) rank 2 or 3, even though the second-ranked male (Trans) was dominant over all three females after three months of age.

To analyze standing-over among individuals, seasons (winter, spring, summer, and fall), and years (2002 vs. 2003), I used a chi-square test of heterogeneity (Microsoft Excel, Microsoft Corporation, www.microsoft.com) to detect for differences. I calculated the expected frequency by analyzing the difference in total spot observations per Coywolf or timeframe (i.e., season or year) by comparing the total number of instances of standing-over observed with the total number of spot fixes per session (i.e., per individual, a specific season, or year).  $P < 0.05$  represents statistical significance.

### Results

I observed standing-over 133 times during the study (Table 1; Figures 1 and 2, and cover). The majority of instances of standing-over were initiated when the Coywolf that was being stood over lay down ( $n = 120$ ). The Coywolf that stood over the lying Coywolf walked up to the recumbent individual and stood over it (Figures 1 and 2) with its inguinal area over the head of the lying animal (Figure 3). Standing-over bouts lasted 10 seconds to 3 minutes (average = 30 seconds) and



TABLE 1. Coywolf gender, intra-sex rank, number of instances of standing-over observed, and number of behaviour observations recorded between April 2002 and October 2003 in a captive pack.

ID	Sex	Rank	Standing-over behaviour recorded	Behavior observations recorded <sup>1</sup>
Cane	F	1	95	14 880
Caon	F	2	12	14 280
Late	F	3	6	14 280
Lupe	M	1	18	14 640
Trans	M	2	2	14 440
Total	3F, 2M		133	72 520

<sup>1</sup>Observations refer to number of spot-sample data points collected every 15 seconds on each individual.

were terminated when the Coywolf doing the standing-over (Figures 1 and 2) walked away or when the individual being stood over (Cover) got up.

While all individuals performed standing-over, the dominant female (Cane) performed the vast majority ( $\chi^2 = 216.8$ ,  $df = 4$ ,  $P < 0.00001$ ; Table 1). In fact, she did more standing-over (95) than the other four Coywolves combined (38; Table 1). Cane performed slightly less standing-over than expected in winter, spring, and summer and more than expected during fall ( $\chi^2 = 9.16$ ,  $df = 3$ ,  $P = 0.027$ ; Table 2). She also performed more standing-over in her second year (2003) than in her first ( $\chi^2 = 135.4$ ,  $df = 1$ ,  $P < 0.00001$ ).

### Discussion

Like the Mech (2001) study of standing-over behavior in wild Wolves, this study found that the dominant female performed the majority of standing-over. Harrington and Asa (2003: 82) mistakenly stated (cf. Mech 2001) that males perform more standing-over and that they do it to advertise hormonal condition, but no data were provided to support this claim. Thus, until more evidence is presented to the contrary, standing-over seems to occur most frequently in dominant female canids, although all individuals may perform the behaviour (Mech 2001; this study: Table 1).

Mech (2001) thought that standing-over was performed to advertise reproductive condition. While I concur, I also believe there are other, potentially subtle, reasons for this behavior in canids. Because the dominant female performed the majority of standing-over in my study pack (Figures 1 and 2), I believe that it is also a non-agonistic way of asserting dominance. Unfortunately, although I did not quantify dyadic standing-over, I did notice that Cane performed more standing-over on the second-ranked female in the pack (Caon; Figure 1) than the others. Most of these instances of standing-over with Caon were not friendly in nature. Caon, in a recumbent position, either ignored Cane standing directly above her, or one of the indi-

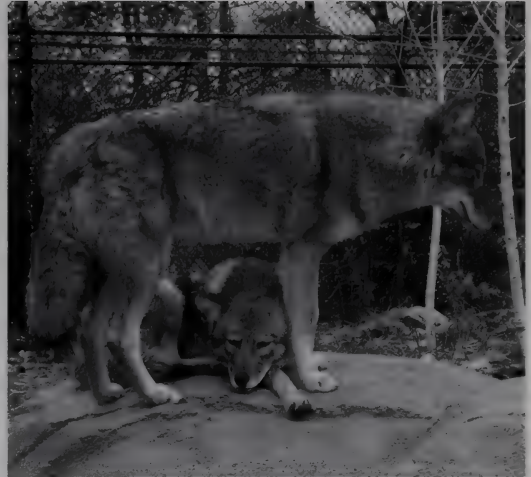


FIGURE 1. Dominant female Coywolf Cane standing over her sister Caon.

viduals exhibited low-intensity growling toward the other. I did not notice friendly or amiable interactions occurring between Cane and Caon during a standing-over. I believe that these interactions would best be qualified as low-aggression interactions. The second most common animal that Cane stood over was the dominant male (Lupe; Figure 2), and I do believe that these instances of standing-over were done to advertise reproductive condition. Lupe occasionally sniffed Cane's inguinal area during these instances of standing-over. Future studies should quantify dyadic interactions more fully when collecting a valid sample size for later analysis.

Cane performed more standing-over than expected during fall (Table 2). She was probably advertising her reproductive condition to Lupe while also passively asserting her dominance over Caon. This coincided with pre-breeding activities before more aggressive behaviors were witnessed in this group during winter (J. Way, unpublished data). It is also of interest that Cane performed more standing-over during her second year than in her first. While this study spanned only the first one and a half years of the animals' lives and ended with the separation of the pack in late-October 2003 due to intra-pack aggression, I did observe Cane performing more standing-over than Caon or Lupe when the three lived together from late 2003 until I stopped observing them in February 2005, just prior to their third birthday (J. Way, unpublished data; Way 2007b). Long-term data on individual Coywolf/canids standing-over behavior would be helpful to elucidate at what age(s) standing-over behavior is most commonly observed.

This study documented standing-over behavior in Coywolves, previously only reported in detail for Wolves (Mech 2001), and it provides additional data showing that it is primarily the dominant female that



FIGURE 2. Dominant female Coywolf Cane standing over dominant male, Lupe.

performs standing-over. Future studies should be longer (e.g., Mech 2001) and should collect more detailed data. Additionally, researchers should also attempt to document standing-over behavior in wild Coywolves and Coyotes.

Acknowledgments

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TABLE 2. Seasonal variation in number of instances of standing-over by the dominant female Coywolf, Cane, of the captive study pack and number of behaviour observations recorded.

Season	Standing-over	Behavior	Expected <sup>1</sup>
	behaviour recorded	observations recorded	
Winter (December–February)	8	1 680	11
Spring (March–May)	26	4 680	30
Summer (June–August)	32	5 760	37
Fall (September–November)	29	2 760	18
Total	95	14 880	

<sup>1</sup>Chi-square expected value calculated based on observations (spot samples) taken per season compared to total instances of standing-over observed and total fixes taken.

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# Another Record of Foliage Roosting in the Little Brown Bat, *Myotis lucifugus*, in Canada

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Huynh, Howard M. 2009. Another record of foliage roosting in the Little Brown Bat, *Myotis lucifugus*, in Canada. *Canadian Field-Naturalist* 123(3): 265.

Another record of foliage-roosting behaviour in little brown bats (*Myotis lucifugus*) is reported. This is only the second such observation ever recorded for this species and the first for Atlantic Canada.

Key Words: Little Brown Bat, *Myotis lucifugus*, behaviour, foliage roosting, Nova Scotia.

At approximately 20:00 h on 8 July 2009, I discovered a solitary bat roosting under a Sugar Maple (*Acer saccharum*) leaf approximately 3.5 m above the ground in a mature mixed forest adjacent to the campus of Acadia University, Wolfville, Nova Scotia. The leaf was green, and it was located near the distal end of the branch. Upon capture, the bat was identified as an adult male Little Brown Bat, *Myotis lucifugus*, the most common bat in eastern Canada (Peterson 1966) and probably the most common species of bat in Nova Scotia (Broders et al. 2003). During handling, the bat became active and emitted distress calls. The bat had one ectoparasitic mite on the right ear and some old scars on the left wing, centred near the posterior edge of the plagiopatagium. Overall, it showed no signs of poor health.

This is only the second record of daytime foliage-roosting behaviour for *M. lucifugus* and the first for Nova Scotia and Atlantic Canada. The first occurrence of such behaviour for this species was observed on 18 July 2004, during a bat survey in Algonquin Provincial Park (Ontario, Canada); that bat (sex unknown) was also observed roosting in *A. saccharum*, near a maternity colony (Davy and Fraser 2007). A subsequent search for additional bat activity near the site of the Wolfville capture before and after presumed bat emergence at dusk on 8 July revealed no other conspecifics or colony nearby. However, bats have previously been observed flying in the area near the forest on several occasions. The fact that the bat reported here was found roosting singly conforms to the species' known life history: male *M. lucifugus* typically roost alone or in small groups, segregated from the females during the reproductive season (Peterson 1966; Fenton and Barclay 1980; Broders and Forbes 2004). Another bat species has also recently been found to roost in foliage in Nova Scotia. The Tri-Coloured Bat, *Perimyotis subflavus*, has been observed roosting in epiphytic beard lichen (*Usnea* sp.), a roosting medium previously unrecorded for the species (Quinn and Broders 2007\*).

*Myotis lucifugus* is generally considered to roost in cavities (Fenton and Barclay 1980). Observations of foliage roosting suggest that *M. lucifugus* may be more adaptable than previously recognized in terms of roost-

ing behaviour. As Davy and Fraser (2007) note, no other North American myotis is so far known to roost in foliage. It is perhaps this adaptability that is responsible for the abundance and widespread distribution of *M. lucifugus* in North America, but more field-based studies would be required to better understand the dynamics of foliage roosting in this species. Observations such as this illustrate that there is still much to discover about the roosting ecology of even common, relatively well-studied bat species.

## Acknowledgments

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# Lone Wolf, *Canis lupus*, Displaced from a Kill by an Adult Black Bear, *Ursus americanus*, in Northeastern Alberta

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Fremmerlid, Mark, and A. David M. Latham. 2009. Lone Wolf, *Canis lupus*, displaced from a kill by an adult Black Bear, *Ursus americanus*, in northeastern Alberta. *Canadian Field-Naturalist* 123(3): 266–267.

Wolf (*Canis lupus*) packs are generally competitively dominant over Black Bears (*Ursus americanus*); however, less is known about lone Wolf–Black Bear interactions. We report an observation of a lone Wolf and an adult Black Bear at a kill made by the Wolf in northeastern Alberta. In this instance, the bear chased the Wolf from the kill site. Our observation supports the hypothesis that Wolf–Black Bear interactions may fit the pattern of asymmetrical interference competition when the interaction involves a lone Wolf rather than a pack.

Key Words: Black Bear, *Ursus americanus*, Wolf, *Canis lupus*, competitive interactions, boreal forest, Alberta.

Larger mammalian carnivore species are generally competitively dominant over smaller carnivore species (Palomares and Caro 1999). Wolves (*Canis lupus*) are widespread carnivores that have sympatric distributions with many other mammalian carnivores (Ballard et al. 2003). Competitive interactions between Wolves and other members of the carnivore guild were summarized by Ballard et al. (2003). These authors reported that outcomes of Wolf interactions with most species fit the pattern of asymmetrical interference competition, but that outcomes of Wolf–Black Bear (*Ursus americanus*) interactions did not. Indeed, Black Bears won only 15% of interactions between the two species (Ballard et al. 2003), despite being 2 to 3 (or more) times heavier than Wolves (Garshelis 2009; Sillero-Zubiri 2009). Reported outcomes include Wolves displacing Black Bears from kills (Gehring 1993) and Wolves killing both young and adult Black Bears (Rogers and Mech 1981; Horejsi et al. 1984; Paquet and Carbyn 1986). However, it has been suggested that this anomaly may be a result of Wolves outnumbering (i.e., hunting or traveling as a pack) Black Bears in such interactions, and consequently having a competitive advantage (Ballard et al. 2003). The purpose of this note is to report an observation of an interaction between a lone Wolf and a Black Bear at a Wolf kill in a Woodland Caribou (*Rangifer tarandus caribou*) range in northeastern Alberta.

On 20 June 2002, during a routine aerial Woodland Caribou relocation survey in the west side of the Athabasca River Caribou range near the town of Wabasca-Desmarais (latitude 55°57'N, longitude 113°49'W), an adult female Caribou was seen moving into a small clearing in a Black Spruce (*Picea mariana*) and Tamarack (*Larix laricina*) fen. Closer inspection revealed a silver-white Wolf trailing closely behind the Caribou and lunging at its hindquarters. While still in the for-

est clearing, the Wolf locked its jaws on to the Caribou's rump. The Wolf and the Caribou remained standing in the clearing, the Caribou with its legs apart in a braced position, for approximately 5 minutes before the Caribou sank to its knees. The Caribou made one final attempt to regain its feet before the Wolf bit the Caribou on the back of the neck near the shoulders. The Wolf did not begin feeding immediately, but rather walked away to lie down. The described sequence of events took approximately 15 minutes in total. No other Wolves were seen with the silver-white Wolf during this observation. Similarly, no other Wolves were seen after a search was conducted of the surrounding area. Upon flying over the kill site approximately 2 hours later, it was ascertained that the Wolf had consumed a small amount of the Caribou's hindquarters.

The following day, an aerial survey revealed a mature Black Bear feeding on the carcass of the Wolf-killed Caribou. A silver-white Wolf, presumably the same individual, was seen close to the feeding bear. The bear left the kill to chase the Wolf, with the two individuals being less than 1 m apart for a brief period. After chasing the Wolf from the vicinity of the kill site, the Black Bear returned to the dead Caribou and resumed feeding. No other Wolves were seen in the vicinity of the kill site during this interaction. Although other accounts of mature Black Bears chasing off (or in one instance killing) lone Wolves have been reported (Joslin 1966; Rogers and Mech 1981), they represent a relatively small percentage of the competitive interactions between the two species — which in themselves remain poorly documented (Ballard et al. 2003). Consequently, this observation supports the claim that Wolf–Black Bear interactions may fit the pattern of asymmetrical interference competition when the interaction involves a lone Wolf rather than a pack (Ballard et al. 2003).



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# Book Reviews

**Book Review Editor's Note:** We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars are AUD and so on.

## ZOOLOGY

### Birds of Brazil

By Ber van Perlo. 2009. University of Oxford Press, 198 Madison Avenue, New York, New York 10016 USA. 465 pages, 150.00 Cloth and 39.95 USD Paper.

Finally we have a good modern field guide to the birds of Brazil. [This means someone need write only a modern field guide for Afghanistan to get full world coverage.]. Most of us have struggled with inadequate guides or having to leave large tomes at home. Now we have a real field book—hallelujah!

So how good is this book? It includes all of Brazil and covers more than 1800 species. These are depicted on 187 colour plates, meaning there are about 10 species per plate. As the page is 9.5 by 6.5 inches, you might expect these plates to look crowded. Most do not, because the illustrations are small and there is a lot white [wasted?] space. With a little work, many of these paintings could have been 20 per cent larger without enlarging the book. Some of the hawk pages [with sex, age, and morph plumages] are, however, cramped. The species sequence does not follow current taxonomy—thank goodness—but instead uses a logical sequence for convenience in the field.

The author, Ber van Perlo, is also the illustrator. He says he has tried to capture a bird's "jizz", but I find many of his illustrations wooden. The albatrosses, for example, lack the slender grace that separates them from other seabirds. The illustrations do improve as you progress through the book, so I found the passerines to be more lifelike. Beware of some copies that are missing yellow on some plates. Check the Green Kingfisher and ensure it is not blue but green. I could not find any evidence of this in my copy, although I did scrutinise the Palm Tanager, as it was grey and showed hardly any yellow-olive tones. All the other birds on this plate were correctly coloured, however. Not all the birds are drawn to the same scale. For example, the 24 inch Hoatzin is shown the same size as the 10 inch Barred Tinamou. This is a concern only where birds of greatly different size are on the same page. So, while these illustrations are not as good as in most other field guides, I believe they are good enough

for most identifications. I do wonder how well you can use this book for the like of the elanias and tyrannulets with flitting birds under field conditions.

The distribution maps show the range for each species as well as seasonality and occurrence. In all, there are 1791 distribution maps, as some introduced species [chicken and guinea fowl] are not included. Personally I find such maps most useful, particularly as they show seasonal changes. This author also adds little red dots for six key cities, giving the visitor some practical reference points.

The introductory material describes Brazil's biogeography, climate, geomorphology, and native vegetation. While brief, this includes some important information, in particular, on five critical plant species. There is an English-Portuguese dictionary of useful terms [all the species names are given in English and Portuguese]. An appendix lists all the numerous endemics.

The text is cryptic, precise, and I thought was fairly useful. For some of the difficult species there might not be enough detail for conclusive identification. The author includes descriptions of calls in terms that generally made sense to me. A good example is the call of the Screaming Piha—a bird that is common, noisy, and is often in the background of South American films.

This guide is far too large for the typical pocket, but it would be fine for a back-pack. Although I was somewhat disappointed in the quality, I am still delighted finally to get a useful, modern field guide, and it is a giant leap forward. I am puzzled by the price of this book. Depending on the agent, the price for the paperback is 40 USD give or take a few dollars, yet the hard copy is around 150 USD. Similar books do not have such a large difference between the cloth and paper editions.

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## **Birds of Eastern North America: A Photographic Guide**

## **Birds of Western North America: A Photographic Guide**

By Paul Sterry and Brian E. Small. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 336 pages (Eastern) and 416 pages (Western), 18.95 USD each, Paper.

There was a time when field guides to North American birds were few and far between. No longer. It seems that every year there is a new entrant into the field guide sweepstakes, with Sterry and Small launching the most recent contender. This review in fact concerns itself with two very similar books, one oriented to the West, the other to the East. Moreover, these are members of a new wave of photographic guides in which the paintings of old are replaced by ever better photos. At first glance, the two volumes are highly attractive books, lavishly illustrated and with superior production values, an impression that largely, but not entirely, remains upon greater familiarity.

The two volumes are twins, sharing the same format, and, where species overlap, the same or very similar text and photos. They consist of the requisite introductory sections followed by species accounts. The introductions touch on the usual items: how to use the book, bird topography, a glossary of terms, tips on bird habitats, and so on. I particularly liked the fact that the tips included a section on urban habitats, which are, after all, where most birders are when not birding! The species accounts follow the taxonomic sequence currently in vogue (starting with waterfowl, not loons) and include plumage descriptions, with subsections on distinctive plumages, where appropriate, followed by sections on voice, status, and habitat, finishing up with an innovative snippet providing observation tips. A few have a "similar species" section where, confusingly, extralimital species are described (confusingly, as other books use this heading to deal with regularly occurring lookalikes). The species accounts are rounded out by crisp, easy-to-read range maps. One advantage of being the latest entry is that recent taxonomic changes are reflected: this is one of the first guides to treat Cackling Goose adequately.

But what about the photos? One of my pet peeves is photographic guides with minuscule dark, grainy photos. No such problem here. The large, bright photos have excellent colour reproduction. Another peeve: guides with just one image of the species. Again, no such problem here. Where distinct plumages exist, there are multiple images; for example, there are eight photographs of Laughing Gull. My third and final peeve: plates in which it is hard to tell which bird belongs to which image. Again, no such problem. Each image is well delineated, so there is little room for confusion. The detail provided and the range of images mean that these volumes will help their target audience, birders, sort out what birds they have seen. This holds for easy-to-identify species but also for the more difficult identifications. A good litmus test for a

North American guide is the treatment of immature dowitchers, a relatively tough identification, but one made easy with the right tools. This book passes that particular test with flying colours, as the distinctively different tertial patterns are easily visible.

There are faults. The division into two volumes, East and West, has resulted in a few oddities; indeed, exactly where the continental divide is remains unclear. Thus, Carolina Chickadee, not usually considered a western bird, shows up in that volume. Similarly, Bewick's Swan, rare enough on the west coast, mysteriously makes an appearance in the eastern volume. To confuse things further, the range maps are the same in both books, showing all of North America. The final pages of each volume have a section on oddities, wherein are grouped various vagrants and escapees, a good idea, but it seems odd to include here Common Ringed Plover, which breeds in the area covered. Similarly it seems odd to relegate Bicknell's Thrush to a section on similar species under Gray-cheeked Thrush. While the inclusion of observation tips for each species is a good move, some of the tips are perhaps less than helpful. For example, the fact that Snowy Owls are white does not make them particularly easy to pick out in a snow-covered field. Likewise, neophytes might wonder why the "easiest to locate by imitating their song" Northern Saw-whet Owl is not responding, as the authors neglect to mention that this works only at night. And you could hike dozens of boulder-strewn rivers in the northeast without ever seeing a Harlequin Duck. And, while on the subject of ducks, Barrow's Goldeneye—said to favour arctic lakes—is a species of wooded ponds in Canada. Some of these faults may have been caused by confusions between East and West (for example, patrolling rocky rivers in the northwest might well produce a Harlequin Duck).

As noted earlier, the selection and presentation of photos are generally good, but there are shortcomings. For example, some of the flight shots of raptors are too shaded underneath. Poor choices have been made in some cases. For example, the only photo of a Cory's Shearwater shows the dorsal side, and this makes it look like an all-dark shearwater, when in fact it is gleaming white underneath. A particular pitfall of photographic guides is that photos are (literally) snapshots in time. The disadvantages of this are apparent in the photos of adult winter Western and Semipalmated sandpipers, which were taken at very different times in their moult sequence. In shorebirds, a few weeks make a big difference, thus the images are not particularly comparable. Similarly, the in-flight shots of

the three accipiters have each one holding its tail in a different way, and this makes it hard to see the differences which are so useful in field identification. There are also some outright mistakes. Ones that I caught tended to be mislabeled photographs: in the eastern volume, the first winter Iceland Gull is actually a second-year bird, the first summer Common Tern is mislabeled as an adult summer (although the same photo is correctly labelled in the western volume), and an immature Yellow-billed Cuckoo is mislabeled as an adult. The range maps are good, but also not

without fault, for example, the Ontario range of Gray Partridge is incorrect.

With the proliferation of options, choosing a good field guide is increasingly a question of personal preference. Most of my casual birder friends prefer photographic guides; most keen birders seem to prefer traditional guides with paintings. I would recommend this book for novice birders and for those wanting to supplement a more traditional guide.

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## A Photographic Guide to the Birds of Jamaica

By Ann Hayes-Sutton, Audrey Downer, and Robert Sutton. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 304 pages, 29.95 USD Paper.

In 1990, Sutton and Downer produced a well-received, handy little photographic guide to the birds of Jamaica. Almost 20 years later, a more comprehensive guide, copiously populated with stunning photographs taken by Yves-Jacques Rey-Millet, makes for a fitting replacement and a fitting tribute to Robert Sutton and Audrey Downer, both of whom sadly passed away before the book was published.

The book follows a well-trodden path, with an introductory section providing a biogeography of the island and observations on the composition and origins of the avifauna and on migration, including austral and altitudinal migrants. There are notes on conservation and threats, a history of ornithology on the island, and a section on birding in Jamaica, including short site notes. This is followed by the obligatory "how to use this guide" section, and there are end pieces, including a section hopefully entitled "probably" extinct species, as well as an annotated list of vagrants and charts highlighting endemic species and subspecies.

As is the norm, the bulk of the book consists of species accounts. Each account includes the often colourful local names and a short taxonomy of the species, followed by a detailed description and discussion of similar species, voice, and, for the visiting birder, an all-important section on habitat and behaviour—usually the keys to finding birds. Each species account is accompanied by a colourful, easy-to-read range map. The most attractive aspect of the book is the photographs. The number of photographs of each species varies, with residents being awarded more extensive coverage, up to four photographs, compared to migrants, which generally have one or two only. For the resident species, all the most likely plumages to be

encountered are illustrated. This bias makes sense, as most users of this book will concentrate on the charismatic local resident species, which include 30 endemics, as the other species are well covered in any standard North American guide. The quality of the photographs is generally excellent; the plates of Jamaican Tody alone are an incentive to start planning your next trip. And then there is the photo of an adult Northern Potoo with a downy white nestling: "When alarmed the chick gradually melds into the parent's feathers, until totally concealed." Now that would be something to witness. Of particular interest to North American birders is a good photograph of the enigmatic Bicknell's Thrush, a hard-to-see northern breeder which winters in Jamaica.

The editing and quality control are excellent. The only slip-up I found was an end piece photograph of a White-chinned Thrush unhelpfully labelled only as "adult", with the reader left to guess what species was involved, a problem easily solved by flipping through the species accounts. A minor quibble: there is a lack of in-flight shots of gulls, shorebirds, and ducks, and this reduces the ability of the book to meet its stated objective to be an all-in-one field guide.

This handy little volume is the only guide you need in order to identify all of the resident birds of Jamaica, along with most migrants you are likely to see. It is also an excellent photographic complement to any of the standard Caribbean regional field guides. The photographs alone make this a handsome addition to any birder's library. I would highly recommend it to anyone with an interest in Caribbean birds and birding.

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## Handbook of Birds of the World. Volume 14: Bush Shrikes to Old World Sparrows

Edited by Josep del Hoyo, Andrew Elliott, and David Christie. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 896 pages, 335 CAD Cloth.

I normally jump to the species plates and descriptions, but this time I stopped at the foreword. This essay on birding is dedicated to Max Nicholson, the man who took us from bird collecting to bird watching. Nicholson was also instrumental in the creation and growth of many initiatives like the British Trust for Ornithology, the World Wildlife Fund, and the Royal Society for the Protection of Birds. The essay "Birding Past, Present and Future: a Global View" by Stephen Moss is an overview history of birdwatching from the pre-binocular era to the present. It gives a fascinating look at our cherished hobby [or is that religion?] using a broad frame of reference. For me, this was an emotional journey, as so much of the text reflected my own past. Moss notes that gasoline rationing ended in 1950 in the UK, making birding travel easier; I got my first bird book that year too. He notes the surge in numbers of birders "from the 1960s onwards"; I joined my first bird club in 1961. He points out the impact of global air travel; I have now birded in 40 countries. Moss explains the change in optics to roof-prism binoculars in the 1970s; I bought my first pair in 1972. The author references the key figures of the last 50 years—Fisher, Peterson, Keith, Snetsinger, and so on—people I have admired.

This volume of the *Handbook of Birds of the World* covers 485 species, including bush-shrikes, helmet-shrikes, vangas, drongos, New Zealand wattlebirds, stitchbird, mudlarks, Australian mudnesters, woodswallows, butcherbirds, bristlehead, bowerbirds, birds-of-paradise, crows, oxpeckers, starlings, and Old World sparrows. Five of these families are large and significant.

The bush-shrikes are a largely African, largely colourful group of heavy, hook-billed passerines. I still recall the pleasure I got from seeing my first Crimson-breasted Shrike, rivalling the nearby Giraffe, also my first. I hope to see more of these species this summer in Namibia and South Africa, home of a quarter of the species.

The birds-of-paradise consist of 42 of the most exotically plumaged birds on Earth. The story of their discovery by Westerners is bizarre and magical. Even today, seeing these birds is difficult and one of the rarest treats in ornithology. They were one of the earliest inspirations for a young David Attenborough. The *Handbook of Birds of the World* artists have done a very fine job of capturing the magnificence of the plumage of these wonderful beasts. So, hats off to *Handbook of Birds of the World* for an excellent job on an impossible task. Yet they still missed something,

I think, as they have shown these birds sitting on a branch [a logical choice] and have foregone the magic of their display. There are wonderful photographs of birds in display, but you really need to be there or at least watch a video to see these spectacles in their true, shimmering glory. There are about 80 photos of birds-of-paradise, 40% of which were contributed by two men, Tim Lehman and Brian Coates. These photos show almost 90% of the species.

The second family is the crows. These birds are easier to depict, as many are black, sometimes with white or grey, although the jays can be remarkably colourful. The real marvel of crows is not their plumage, but their intelligence. I was not surprised to read that the American Crow has the largest brain in relation to body size of any bird. I have always had a great fondness for crows, as they normally give a good performance. Like teenage boys, they are usually up to something. New World warblers may be more showy but all they do is eat and sing. Yet Carrion Crows stand with humans at crosswalks so they can place nuts on the road when traffic is halted. After the nuts are crushed, the crows follow the pedestrians and collect their meal. Other crows have been seen making tools.

For all my life, I have only lived in the range of the European Starling [*Sturnus vulgaris*], so I am prejudiced by constant contact with a dull, noisy and trouble-causing bird. In my travels, however, I have seen some stunningly striking starlings. What could be more brilliant than the aptly named Superb Starling, captured nicely in this volume of *Handbook of Birds of the World* by the artist and photographer. This group also includes the troublesome but entertaining mynahs.

The last group is the Old World sparrows, containing the famous, or infamous, House Sparrow. The range for this species is given as the "real", original range. Only in the text does it say that it is introduced in South Africa, the Americas and Australia. Even this is weak, as it occurs in southern Africa south of Zambia and all the Americas, except the dense rain forest. The same is true for the Common Myna and the Common (European) Starling.

Again the *Handbook* gives a broader perspective of the Old World sparrows beyond the ubiquitous House Sparrow. Although most bear a fair resemblance to this species, there are two bright yellow and one chestnut sparrow in the family.

Technically this volume is carefully researched and accurate. The only entry that confuses me is the inclusion of the Arabian Magpie [*Pica (p.?) asirensis*] as a full species, while not giving the Korean Magpie

[*Pica sericea*] species status. The last paper I read had DNA evidence supporting four species—European Magpie (*Pica pica*), Yellow-billed Magpie (*Pica nuttalli*), Black-billed Magpie (*Pica hudsonia*), and the Korean Magpie.

With the publication of this volume of the *Handbook*, the editors need only to maintain their amazing standard for two more volumes, due by 2011.

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## Corvus: A Life with Birds

By Esther Woolfson. 2008. Granta Publications, 12 Addison Avenue, London W11 UK. 337 pages, 17.95 CAD Paper.

In the British countryside, rooks are renowned for their intelligence. They are a member of the corvid family, smaller than crows, and are colonial nesters. Some rookeries have been in existence for centuries, each generation repairing and improving the winter damage, spending the summer raiding crops and outwitting all efforts by farmers to keep them away.

*Corvus* is not just an account of the life of a rook Woolfson took into her home in Aberdeen. The first chapters of the book describe her other avian lodgers—an irascible cockatiel and a depressive parrot, and, in the garden, a dovecot full of doves. Her relationships with the birds are never anthropomorphic. But it is “Chicken”, the rook, who is the star of the household with her intelligent problem-solving and interaction with people. Chicken had free run of the house, but her clipped wings were no impediment. She climbed stairs, sat on chairs, and perched on the top of cupboards. With the cupboard door ajar, she would set a booby trap: she would balance a pencil across the opening and, when the door was shut, the pencil landed on a human head. There were delighted cries from the trickster. Woolfson has read extensively both in the scientific journals and accounts in literature, so her speculations on bird brain capability ring true.

Among birds, the members of the corvid family have the largest brains in relation to body size. They

will use tools to obtain food, and they can recognize themselves in a mirror. “Self-recognition” is rare in animals and only dolphins, elephants, apes, and humans have the capacity to do so. Woolfson is careful always to question her conclusions about bird intelligence, but the evidence makes one wonder what other word can explain some of the incidents described. There are episodes of (in human terms, for lack of an alternative) anger, frustration, fear, anxiety, pleasure in greeting, regret at parting. Single words are clearly understood by the rook, and she in turn has a range of calls in reaction to events. Her memory was impressive. An interesting behaviour is her reaction to different music composers. Benjamin Britten’s music always caused a dramatic exit from the room with loud squawks; Schubert and Bach seemed to soothe. The latter part of the book discusses the intelligence and behaviour of birds, the depth of their emotional responses, and the degree to which these may be the result of problem solving by the brain as opposed to intuitive or innate solutions. The quality of the writing is exceptional and at times poetic. This was a pleasure to read. The revelations are fascinating.

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## The Curse of the Labrador Duck

By Glen Chilton. 2009. Harper Collins, Toronto, Ontario, Canada. 288 pages, 29.99 CAD Paper.

This is a bizarre, irreverent, idiosyncratic, but entertaining travelogue. Glen Chilton’s travels come close to rivaling those of fanatical birders such as Phoebe Snetsinger and Richard Koeppel, birders who have written about the nearly 8500 and 7080 bird species they encountered, respectively, in expensive worldwide trips. Like them, Glen Chilton travelled extensively. Unlike them, he wasn’t looking for live birds. He flew 72 000 miles, went 5461 miles on trains, 1168 miles on buses, and 3466 miles in automobiles, all to view *dead ducks*. He visited 55 specimens of one extinct species, the Labrador Duck, last seen alive about 1875. He also visited the most plausible Labrador Duck nesting site, identified as such by John James Audubon on 28 July 1833, at Blanc Sablon, Labrador.

Prior to writing *The Curse of the Labrador Duck*, Chilton was first author of the species accounts for the White-crowned Sparrow (1995) and Labrador Duck (1997) in the landmark *Birds of North America* series.

This book is an entirely different kind of birding book. Chilton’s pursuit of Labrador Duck specimens follows the pattern of a detective story, though a detective story told with charm and full of humour. Truth about the Labrador Duck is stranger than fiction, as he tells us about museum goals and procedures and we meet the dedicated collection curators. Some of the latter were extremely cooperative; others he describes as “grumpy.”



Chilton reveals that all nine of the supposed Labrador Duck eggs in the world have been misidentified. DNA analysis shows that eight were Mallard or domestic duck eggs and one was that of a Red-breasted Merganser! The finest Labrador Duck specimen extant is a male in the Royal Ontario Museum in Toronto; the other two Canadian specimens are in the Canadian Museum of Nature in Ottawa and the Redpath Museum at McGill University. Chilton visited all 26 specimens in the United States, and in Europe he visited digressions in nine countries: six each in England and Germany, three in France, two each in the Netherlands, Austria and the Czech Republic, and one each in Belgium, Ireland and Russia.

What are the weaknesses of this book? It is too subjective, sometimes too detailed, occasionally salacious, and at times repetitive, with overly long digressions away from Labrador Ducks. Chilton consistently refers to "stuffed" specimens whereas an ornithologist should speak of "mounted" specimens. The book also lacks an index and a bibliography.

Chilton has chosen to deal only with the extinction of this single species, passing up an opportunity to use it as a wake-up call to help prevent additional extinctions. The other issue that might well have been empha-

sized is the parlous state of finances of some of the major museums he visited; environmentalists need to know that inadequate operating budgets threaten the function, and sometimes the long-term existence, of these centres of knowledge and culture in many parts of the world.

Time will prove whether Chilton's confidence in having visited every Labrador Duck specimen in the world is justified. It is a measure of his obsession and his dedication that if someone unearths a specimen new to him, he will pay from his pocket a \$10,000 reward!

Chilton has saved his best chapter for the end—the exciting detective episode involving the final (55th) Labrador Duck specimen. Except for a brief note in *The Auk* in 1952, the carefully hidden details of this mysterious specimen have long remained a secret. Chilton reveals many of the devious twists and turns relating to the eight people who had possession of the specimen after it had resided for 100 years in an unnamed country house in Kent, England. I won't spoil his climax; I suggest you read this story for yourself.

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## What Originally Prevented, and What Later Permitted, the Great Northern Expansion of White-tailed Deer?

By D. Strickland. 2009. Occasional Papers from Oxtongue Lake Number 1. The Friends of Algonquin Park, Whitney, Ontario. 40 pages, 4.95 CAD Paper.

During the late 1800s and early 1900s, White-tailed Deer spread north throughout the eastern United States to Quebec's Anticosti Island and have maintained exceedingly high numbers for more than 70 years. Those deer, in fact, have had a drastic impact on the island's vegetation, eliminating most browse species in addition to converting former Balsam Fir forests to White Spruce. Over-browsing by deer on Anticosti has been so severe that both Black Bear and Rock Ptarmigan have been eliminated through competitive exclusion. Thus, Anticosti is much poorer deer habitat than either northern Minnesota or Algonquin Park in Ontario, yet the island is still overrun with White-tailed Deer while the other areas are not. In addition, winter weather is more severe on Anticosti than in either the rest of Quebec or in Minnesota. Anticosti, though, is predator-free, while Wolves and other carnivores are common on the mainland. This and other evidence led the author to conclude that predation, not habitat, controls the distribution and abundance of White-tailed Deer.

The author then develops what he calls the suitable alternative prey hypothesis to explain the past and present distribution of White-tailed Deer. In the scientific literature, this is more commonly known as predator-mediated or apparent competition, though the author uses neither term. According to the author, the range

of the Moose historically extended further south than it does today. By subsisting on Moose, Wolves took the smaller and more vulnerable deer to very low levels or local extinction. As European settlement eliminated Moose from the southern part of that animal's range and at the same time the settlers controlled Wolves, White-tailed Deer expanded northward. Similarly, the reason White-tailed Deer have now just about been eliminated from Algonquin Park and northern Minnesota is that Wolves survive by preying on Moose, and this allows the predator to keep the more vulnerable deer from recovering.

While this might be a new idea to some, predator-mediated competition or exclusion is not that rare. According to Dr. Tom Bergerud and others, Moose-fuelled Wolves today are in the process of exterminating Woodland and Mountain caribou across the length and breadth of Canada, while Elk-fuelled Wolves have recently been instrumental in eliminating Caribou from Banff National Park and are doing the same in Jasper National Park. Similarly, Wolves are in the process of wiping out Elk from parts of Yellowstone National Park. Since at least the 1950s, 600 to 700 food-limited Elk have wintered in thermal areas along the Firehole, Gibbon, and Madison rivers in the west-central portion of Yellowstone. This herd is isolated during winter

and the animals do not leave the protected area, i.e., these Elk are not hunted. Following the reintroduction of the Wolf, however, those predators have annihilated the Elk, with researchers predicting extinction—see Garrott et al. (2008). This is because Bison are available as an alternate prey. In fact, if the easier-to-kill Elk did not have a partial refugium by fleeing into the Madison River when attacked by Wolves, the Elk would already have been exterminated. The habitat is still there—after all, this is a national park—but the Elk are not.

So while this Occasional Paper focuses on the problem of the expansion of the range of the White-tailed Deer in the eastern US and Canada, it also addresses the age-old question of whether ecosystems are structured from the top down (termed “predator-limited”) or from the bottom up (called “food-limited”). According to the author, “if the aim of management is to increase the number of [ungulates]... habitat improvements will necessarily be futile unless predation is stopped from removing the annual increment of [the prey population].”

I would recommend this publication to people with an interest in forest management, ungulate ecology, or predator-prey relationships. Parts of the Occasional

Paper, though, can be difficult to follow because of the unique abbreviations the author uses to explain his graphic models. For instance, *kpd* refers to “predation-devalued carrying-capacity.” The author also refers to what he calls “pre and post-settlement” ranges of Moose, White-tailed Deer, and Caribou, when what he really means is pre- and post-European settlement—the entire continent having been settled by indigenous peoples for at least the last 10 000 years. In addition, I would like to have seen data on archeologically recovered faunal remains to support the author’s Moose, White-tailed Deer, and Caribou “pre-settlement” maps, as well as a discussion of aboriginal hunting. If, as the author concludes, Wolf predation was of overriding importance, surely native hunters would also have had some effect on prey numbers and distribution, especially since others have noted that human hunting and carnivore predation are additive, not compensatory.

#### Literature Cited

Garrott, R., P. White, and F. Watson. Editors. 2008. *The Ecology of Large Mammals in Central Yellowstone, 3. Sixteen Years of Integrated Field Studies*. Academic Press/Elsevier. 712 pages.

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### Turtles: The Animal Answer Guide

By Whit Gibbons and Judy Greene. 2009. Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363 USA. xiv + 163 pages, 45.00 USD.

*Turtles: The Animal Answer Guide* organizes a variety of basic information on turtles into a handy question and answer format. If anyone is qualified to write such a book it is this duo. Whit Gibbons, a professor emeritus at the University of Georgia, is a pre-eminent turtle researcher, with turtle publications dating back to the 1960s, including editing the classic volume *Life History and Ecology of the Slider Turtle*. Judy Greene is the herpetology research coordinator at the Savannah River Ecology Laboratory. Together they have captured or recaptured over 30 000 turtles.

The book is divided into 12 chapters: Introducing Turtles, Form and Function, Turtle Colours, Turtle Behaviour, Turtle Ecology, Reproduction and Development, Foods and Feeding, Turtles and Humans, Turtle Problems (from a human viewpoint), Human Problems (from a turtle’s viewpoint), Turtles in Stories and Literature, and “Turtleology”. So, for example, in the chapter Introducing Turtles, there are questions such as What are turtles? Where do turtles live? When did turtles first evolve? What is the largest fossil turtle? And the chapter entitled “Turtleology” has questions like Who studies turtles? Which species are least known?

All of the 100+ questions are listed in the table of contents, making it is easy to determine if a particular topic is covered. The questions were assembled from the most common questions the authors have been asked over the years. Can turtles see colour? Do turtles

play? Where do turtles sleep? How long do turtles live? One obvious question that is missing is how long turtles can stay under water. The authors only partially tackle this topic, with the question Can turtles breathe underwater?

Overall, the answers are thorough without getting bogged down in excessive detail, although occasionally the answers are too cursory. For example, temperature-dependent sex determination in turtles is discussed, but not the possible reasons it evolved. There is also some overlap among the topics covered under different questions, and this can result in some discrepancies. Fibropapilloma, a tumour-causing disease, is discussed in the answer to two different questions. In one answer the authors correctly state that it affects some species of sea turtles, particularly the Green Sea Turtle (page 53), but in the other answer it states that it affects just Green Sea Turtles and it is unknown whether it will develop as a problem in other species (page 93).

Overall, though, this is a wonderful book. It is built on a solid foundation of the essential biological facts that you would expect in any decently written book on the subject, but it is also infused with wonderful tidbits of personal experience that come from spending a lifetime studying turtles.

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## BOTANY

**620 Wild Plants of North America**

By Tom Reaume. 2009. Canadian Plains Research Centre, University of Regina, 3737 Wascana Parkway, Regina, Saskatchewan S4S 0A2 Canada. 784 pages, 80.00 CAD.

"An old fertile ditch replete with wildflowers is a wonderful place to spend a summery morning." This introductory remark, which will resonate with many field botanists, clearly reflects Tom Reaume's dedication to his subject matter. Focusing on the three prairie provinces and the US Midwest, this attractive book provides detailed studies of 620 vascular plant species representing 89 families.

Not intended as a regional flora (Manitoba alone has 1640 plant species) or as a field guide (because of size), the book has significant features which will endear it to readers. Each plant family is given a thorough introduction along with copious sketches. For example, the introduction to Asteraceae, a large and complex family, is two pages of text and 25 illustrations. Very few botany books dedicate a whole page to each species, but this one does. Variety is provided by having illustrations follow the shape of the plant, then moulding the text to fit the sketches. The most endearing features are the countless exquisite drawings. All accounts of species, even weeds, are accompanied by excellent range maps covering the northern Great Plains. Accounts include two interesting indices, new to this reviewer but clearly of value:

1. Native Prairie Restoration Priority, mainly applicable to the prairie provinces
2. Wildlife Use of Birds and Mammals—the degree of importance to wildlife.

Most of the plants are drawn from life, at sites in Manitoba and Saskatchewan. Often plants were visited several times in the field until the fruit was ripe. The author reports that his favourite object to sketch is the fruit (i.e., the seed) of any plant, particularly one with some texture. Plant descriptions rely mainly on common-use words, a pleasant contrast to certain botanical manuals with a seemingly perverse preference for technical terms. The taxonomy seems up to date or at least as up to date as possible, given the rapid changes we are now experiencing.

The book is graced by a very extensive list of references, suggested websites, and excellent indices to both common and scientific names. As well, the extensive glossary has many terms cross-referenced to illustrations. Odd and intriguing words such as "ladderling", "verticillaster" and "anther head" are clarified.

Although not formally trained in botany or illustration, the author states that his interest in both has

expanded during this 12-year project, clearly a labour of love (he has donated all original drawings and royalties to Nature Manitoba). My enjoyment was increased by the addition of poetic quotes and non-botanic decorative drawings. I agree with Reaume's suggestion that this is a wintertime book to be enjoyed as much for the beauty as the science. Best use would be as an illustrated companion to existing floras and wildflower guides.

The author determined the boundaries on the range maps, a daunting task considering the huge territory involved and the number of naturalized plants. In doing this he discovered a "surprising glumey floral secret"—there are only a few Canadian and American herbaria with current dot-distribution maps on file for all species found in their province or state. Botanists and collectors associated with herbaria, except for a precious few, apparently lack the will, money, or genes for mapping. In defence of his own province, he notes that the two largest herbaria in Manitoba do have these maps. Certainly in this reviewer's opinion, the biggest hurdle to the study of botany in Ontario is the lack of publicly available range maps for all species. The author also suggests that current mapping should now segregate year 2000 and subsequent records from those prior, as he fears a large number of plant species will disappear during this century.

As minor criticisms one could note the book provides very complete species descriptions but no general remarks (e.g., readers are left in the dark as to the intriguing etymology of Garden Atriplex (*Atriplex hortensis*), a widespread native species). Species accounts could have been improved with global ranking or degree of invasiveness. Some readers may decry the lack of an identification key; however, keys work well only when most species within the book's territory are covered, not the case here.

Designed for both professional and amateur botanists, this book will be valuable both as a botanical text and as a reference. The superb illustrations, the very legible print, and the excellent maps render this a lovely book, a pleasure to hold and read. Even to an Ontarian, it represents an important addition to a botanical library.

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## China Resource Plants

By Zhu Taiping, Liu Liang, and Zhu Ming. 2007. The Science Press of China, 16 Xizhimen South Street, Beijing, China 100035. 1220 pages, 195 Yuan RMB Cloth.

China is a vast country extending across a number of climatic zones. Diversified ecosystem types, complex terrain, and heterogeneous natural environments allow for an abundance of plant species, among which resource plants have played important roles in the Chinese national economy and people's daily life. There are 365 families of seed plants, about 3400 genera, and 32 000 species of higher plants in China, of which about one-tenth have been used by Chinese since ancient times. Key techniques, such as breeding, cultivating, and methods of use, have been developed, and this is one of the great contributions of Chinese to human civilization. However, these resource plants have not been systematically reviewed and summarized for a long time.

Recently, a comprehensive and systematic book on the resource plants of China was written by Zhu Taiping, Liu Liang, and Zhu Ming. The book is based on the data accumulated during about 50 years of field investigations on plant resources by the authors, and it includes literature from China and elsewhere.

The development of botany in China was rather slow for thousands of years, and in-depth systematic and interdisciplinary research on resource plants was even slower. It was only about 50 years ago after the establishment of P. R. China, a resource plant research lab in the Institute of Botany, Chinese Academy of Science, was established. This heralded the beginning of research on resource plants. Gradually, other research institutes or labs for resource plants were established in various institutions of China, and the research spread across China.

Although this new book covers nearly 2800 species of resource plants, it is only a preliminary introduction compared with the total of more than 30 000 species of plants in China. Full research on and a summary of these plants obviously requires a longer time and more work by more Chinese scholars.

Because of the environmental problems caused by overuse of fossil fuels and the limits of underground non-renewable energy, as well as the sustained increase in international demand for energy and soaring oil prices, more and more countries have begun to turn their attention to the exploitation of alternative, environmentally friendly, and renewable energy sources. Biofuel has been a focus due to its advantage as a renewable and environmentally friendly resource, and it may become at least a part of future energy. For example, ethanol production from plant fibre has become commercially competitive in some countries, and it may at least reduce the emission of greenhouse gases by 50% compared to using petroleum. We believe that full exploitation of resource plants may

bring a new opportunity for human society in dealing with the issues of the energy crisis and environmental protection. Of course, the protection and sustainable management of resource plants themselves must be also reinforced.

The book is composed of seven chapters. The first chapter discusses the general aspects of plant resources and their relations with the environment and humans. Then it introduces the progress of plant resource use and the main characteristics of plant resources in China. Chapter two expounds the important characteristics of resource plants and comprehensively introduces 15 major categories of resource plants worldwide, but with a focus on Chinese species, such as plants with a high fibre content, starch, protein, amino acids, vitamins and lipins, pigments, essential oils, gum and pectin, tannin, resin, rubber and gutta, medicinal materials, and those with sugar or non-sugar sweet additives, as well as decorative flowering plants, involving nearly 2800 species. Chapter three describes the distribution of some chemical compounds in plant taxa and the relationships with the geographical environment, and it also discusses the main tasks of the research on plants. Chapters four and five describe examples of research on some typical resource species. Chapter six introduces the contribution of China to the world in the use of some typical Chinese plants. This chapter gives brief histories and the present situations of some important crops, fruit trees, medicinal plants, and natural herbs bred, cultivated, and exploited by our Chinese ancestors, including plants such as rice (*Oryza sativa* L.) (going back 8000 years), Japanese barnyard millet (*Setaria italica*) (6000–7000 years), pearl or cattail millet (*Pennisetum glaucum*) (4000 years), sorghum (*Sorghum bicolor*) (5000 years), buckwheat (*Fagopyrum esculentum*) (2000 years), soybean (*Glycine max*) (4000–5000 years), red bean (*Vigna angularis*), mung bean (*Vigna radiata*) (2000 years), Chinese cabbage (*Brassica chinensis*), cole (*Brassica campestris*), mustard (*Brassica juncea*), radish (*Raphanus sativus*), marijuana (*Cannabis sativa*), ramee (*Boehmeria nivea*), tea plant (*Camellia sinensis*), peach (*Amygdalus persica*), apricot (*Armeniaca vulgaris*), plum (*Prunus salicina*), cherry (*Cerasus pseudocerasus*), jujube (*Zizyphus jujuba*), lichee (*Litchi chinensis*), waxberry (*Myrica rubra*), Chinese white olive (*Canarium album*), persimmon (*Diospyros khaki*), Chinese gooseberry (*Actinidia chinensis*), pear tree (*Pyrus*), and orange tree (*Citrus*). Chapter seven discusses the sustainable use and protection of resource plants.

The book is well written with few errors. Abundant illustrations will help readers easily understand the results. One criticism of the book may be that the seven



chapters are unbalanced in terms of length and depth of information and they are sometimes not very closely or logically linked. This is especially true for chapters four to seven. Nevertheless, the book is valuable for its systematic summary and theoretical analysis of the accumulated information on Chinese resource plants. As well, it makes a significant contribution to practical guidance in research and the exploitation of resource plants for scientists both in China and in other countries. The book is suitable for professionals who engage in

botany or relevant sciences and for other persons who are interested in these fields.

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## **Figs, Dates, Laurel, and Myrrh: Plants of the Bible and the Quran**

By Lytton John Musselman. 2008. Timber Press, 133 SW 2<sup>nd</sup> Avenue, Suite 450, Portland, Oregon 97204 USA. 314 pages, 21.28 USD.

As a child, I always thought that the mustard plants to which the biblical authors referred must have been a Middle Eastern plant different from the mustard which grows in this country. After all, the mustard in this country is not the smallest of all seeds, it is a smallish seed, an oil seed which can be ground up and mixed to produce the sweet mustard of hot dogs and a common condiment. If it were the smallest of all seeds, I never saw it. If it could grow into the tallest of shrubs where birds could come and nest in its branches, it had to be different from the yellow rocket mustard of eastern Ontario. There was no support for a bird's nest here, simply a weed found in the garden. So when Musselman's book arrived on my desk, mustard was one of the first plants I looked up, and I was surprised to find, after all these years, that the mustard of the Bible was not much different from the mustard of Ontario, not larger, not with a smaller seed, but a biblical plant to which Jesus made reference as a point of faith, not a wonder plant. Of course, the image Jesus used was to make a point about the wonderful action of God, far more than we could imagine and where the normal could become amazing. The usual could become wonderful.

In this book, 81 different plants are taken from all parts of the Bible and identified by a botanist who loves plants, loves the Bible, and loves the Middle East. Familiar plants like the grape, apple, thistle, wheat, and olive and many trees, vegetables, flowers, and spices are enumerated and described in detail. Sometimes different species and often different genera are substituted for the names the Bible translation uses to refer to the common fruits which we know. Some other plants like nard, wormwood, myrrh, and gall are exciting to consider. These are the biblical images which are associated with different stories in the Old and New testaments and become old friends to scripture readers with images of the Magi, the "holy waste" of people's reverence for Jesus, and some kind of bitter product which can be the fruits of souls destroyed by sin and death.

Interesting ideas borne of botanical studies are interjected into the text when the real fruit has no Middle Eastern presence in antiquity. The classic image of the apple is critiqued with reference to the Garden of Eden, where the fruit is not named but has been accepted as the fruit of the tree of good and evil. Our translations of the books of Joel and Proverbs contain the word "apple" but other fragrant and sweet fruits like the apricot may be a better translation of the Hebrew word used in the text. Musselman mentions these differences and refers to historical works which trace the development of the myth.

Some plants have no clear identity in modern botany. Gall, the ingredient in the bitter mixture which was offered to Jesus to drink on the cross, is one such reference which may have a lot of candidates but no clear definition. It could be the bodily fluid. It could be a poison. It could be one of a number of weeds like poison hemlock, wild carrot, or even poppy. All are bitter to grazing animals, but the Greek word in the text is properly translated as "bitterness" rather than any one plant.

Reading the scriptures and then referring to the descriptions in Musselman's text was a pleasant and thoughtful exercise which deepened my understanding of the text which I was reading as well as the botany of the Middle East. I worked my way through the book for many thoughtful hours considering myths and icons and now comparing botany to biblical images. Many of us read the scriptures considering the lilies of the field in a metaphorical sense when they were presented to us. Seldom do we consider them as botanists, and as I read this book I was forced to consider the real plants instead of simply the metaphor. I found that changing my perspective of reading the Bible enriched the images which, as a believer, I have considered so long and so often in the scriptures.

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## ENVIRONMENT

**Russia and the North**

Edited by E. Wilson Rowe. 2009. University of Ottawa Press, 542 King Edward Avenue, Ottawa, Ontario K1N 6N5 Canada. 218 pages, 22 USD.

This book makes for an interesting document in time. It's a traditional-style western information source on Russia and its Arctic policy, but also on Norwegian perspectives. It is written by nine authors (six from Norway, only two from the US, and just one from Russia). The editor is E. Wilson Rowe from the Fridtjof Nansen Institute in Oslo, Norway. The central schemes of this book are wrapped around the economic developments in the Barents Sea and the Kara Sea, and thus Russia's claim to the North Pole, prominent oil and gas topics, fisheries issues, interfering indigenous perspectives, and climate change are dealt with. Most readers will appreciate learning about Russian's history of decision making and its fluctuating long-term strategy, as well as facts and underlying reasons for building "Fortress Russia" and its peculiar and globally inconsiderate behaviour of "muscle building".

The editor starts with a nice introduction to Russia's aims and realities ("The North accounts for twenty percent of Russia's gross domestic product", "...and paid forty-seven percent of all taxes collected by the Russian state in 2006."). However, no statement is made that Russia's shock therapy to capitalism widely failed and resulted, for instance, in shorter life expectancies. P. Baev from the Peace Research Institute of Oslo (PRIO) presents the first chapter on Russian military strategy and related activities: Russian development clearly means militarization!

The second chapter, by G. Hønneland (Fridtjof Nansen Institute, University of Tromsø), deals with cross-border cooperation in the Barents Euro-Arctic Region (BEAR), involving Norbotten (Sweden), Lapland (Finland), Murmansk Oblast, Arkhangelsk Oblast (region), and the Republic of Karelia. Namely, work of the Barents Euro-Arctic Council (BEAC; Canada, France, Germany, Italy, Japan, the Netherlands, Poland, UK, and US all have strategic observer status) gets described. The fact that Russia ignored many environmental issues (for instance, for the infamous Pechenigikel combine; Norilsk Nickel smelter) is documented, as is the fact that conflicts between the Federal Service for Surveillance in Ecology and Resource Use (Rosprirodnadzor) and the Federal Service for Ecological, Technical and Nuclear Surveillance (Rostekhnadzor) resulted in (purposeful?) confusion and inefficiency for no relevant change. Once joint ventures became profitable, Russia reaped many economic advantages for itself at will in BEAR. But on the good side, personal relationships on all sides of the borders benefited greatly within BEAR and its initiatives, e.g., the indigenous Lapp people.

The third chapter, by C. ZumBrunnen (University of Washington, Seattle), is among my favourites. It

deals primarily with climate change in the Arctic and its implications for Russia. This highly informative section describes relevant Russian statistics and indicators showing climate change in the Russian Arctic beyond any reasonable doubt, causing many pipeline breaks and affecting industrial population centres and the Trans-Siberian and Baikal-Amur railways. These facts matter, because for a long time the head of the Russian Academies of Science Institute of Climatology and Ecology (Yu. Izrael) and the head of the Institute of the Earth's Cryosphere (V. Melnikov) stated, in a self-serving manner for Russia's oil industry, that climate change would actually be good for the country and more CO<sub>2</sub> should therefore be put into the atmosphere! Together with the infamous citations by A. Illarionov (economic adviser to V. Putin) comparing the Kyoto Protocol to fascism and stating that the "...theory of global warming is not borne out by scientific data and is, strictly speaking, charlatanism", this documents Russia's traditionally egoistic and poor leadership all over again. Further, Russia's problem with flaring gas gets described (an environmental/economic waste and an oddity when wanting to reduce carbon emissions). This is nicely balanced by ZumBrunnen, who outlines Exxon Mobil's 16 million USD campaign to distort the facts of climate change and the fact that the Bush administration interfered with climate science, imposed censorship on its scientists, and blocked the ratification of the Kyoto Protocol in the United States. (Russia did ratify it, and the EU supported Russia's application to join the World Trade Organization right afterwards!) The author states that Russian CO<sub>2</sub> output is directly related to its economic performance (it basically means that Russia accumulates wealth at the cost of the global community).

Another informative chapter is written by A.-K. Jørgensen (Fridtjof Nansen Institute), who is also a fisheries observer in Russia. Jørgensen elaborates on the subject of (Arctic) fisheries. The Arctic cod stocks are among the largest in the entire Atlantic, and the bulk of the contractually shared Norwegian-Russian resource swims on the Russian side. The author describes intense Russian overfishing of many Barents Sea stocks, Russia's resistance to recommendations by the International Council for the Exploration of the Sea (ICES), and the inherent crime and corruption of Russia's "unreformable" fisheries sector and the Federal Research Institute of Fisheries and Oceanography (VNIRO). Further, the Murmansk trawl fleet, subsidies, quota trading, and governmental attempts to overcome problems by means of restructuring (Law 303), as well as open market approaches to fish auctions that worked nowhere else, are discussed (views from



D. Pauly et al. are unfortunately ignored, though). Noteworthy is the fact that Russia has a policy to provide each citizen with a guaranteed 26 kg of fish per year.

Another crucial topic of relevance to world security—Russia's offshore oil and gas resources—is taken on by A. Moe (Fridtjof Nansen Institute) and the editor herself. The Soviet Union has been among the world's largest oil and gas producers in the world. This picture has hardly changed, and the EU—widely without such natural resources—is still among the biggest consumers of Russian gas. The Arctic is perceived as a safe location for oil and gas production (a view everybody should take issue with). GAZPROM (with close political ties to D. Medvedev) is the largest gas producer in Russia, and likely in the world, carrying the export monopoly, whereas ROZNEFT is stronger regarding oil production, but is closely affiliated with V. Putin. Both companies interfere but basically obtained the Russian monopoly through law. Not just Norwegian STATOIL and Russian GAZPROM and ROZNEFT cooperate in the Barents Sea, but companies like French TOTAL are also involved. Global security issues and NATO must be considered here, too. The Russian off- and onshore development of carbon resources includes liquefied natural gas (LNG). Development and leasing strategies for the next 40 years in the Pechora Sea, the Shtokman gas field in the Barents Sea, Ob-Tazov Bay, and the Kara Sea are outlined.

A subsequent chapter by T. Heleniak (University of Maryland) on growth poles (industrial centres) and ghost towns tackles the general notion of “fleeing the Arctic”, poverty traps for immigrants (such as Chukotka and Magadan), few new immigration centers (such as Tuva), long-distance shift-work, and the Bishkek Protocol. As found elsewhere, globally failed World Bank policies became clear once more when the World Bank borrowed 80 million USD in 2001 for the Northern Restructuring Project, naively trying to promote economic growth in the Arctic. But Russia overrules economic arithmetic with political means.

It's easy to detect in this book the fact that the 39 indigenous peoples in Russia have no direct voice in this book, e.g., via representatives of RAIPON (Russian Association of Indigenous Peoples of the North). But two chapters are devoted to them. I. Øverland from the Norwegian Institute of International Affairs presents fresh perspectives on (international) indigenous rights: Convention (labour standard) 107 of the International Labour Organization (ILO) and its update, Convention 169 (not signed by Germany, for instance). Article 69 of the Russian constitution “...guarantees the rights of small indigenous peoples in accordance with the generally accepted principles and standards of international law”. But without ratification of the new ILO 169 Convention, such words are becoming a farce. Other crucial topics are the legal definition of indigen-

ousness, recognition of indigenous groups as peoples (Article 1 of the Charter of the United Nations), and the relevance of urban lifestyles (15% of the northern indigenous population in Russia is still nomadic). Other aspects of this chapter are centered on subsurface rights (e.g., for oil, gas, and mining), which are mostly owned by the government and international corporations.

Finally, A. A. Sirina presents a voice from the Russian Academy of Sciences, outlining the inherent conflict between oil and gas development and northern indigenous people, such as the Evenki and Yakut. It is shown that 60% of the federal budget comes from revenues from exporting oil and gas and that ethno-territorial bodies were used by the regional oil and gas elite to achieve their own political goals. Examples are found in the Eastern Siberia–Pacific Ocean (ESPO) oil pipeline, the world's longest pipeline (it had the infamous routing problem near Lake Baikal).

The afterword by the editor shows the intersection of northern and national policies and why Russia thinks it can afford to be so assertive at most levels (e.g., the Arctic Military Environmental Cooperation program—AMEC—signed by Russia, Norway, and the US). Instead of modern and careful diplomacy and world peace, V. Putin still seems to be trying to restore Russia's great power status and using vertical structures. But there can be no doubt about the geo-strategic role of Siberia, e.g., large nickel, gold, lead, coal, and silver resources are located at a crucial international crossroad linking the Arctic, Europe, Asia, and the Pacific Rim. The book leaves no doubt that the new Russia is aggressive and puts no relevant emphasis on environmental issues. Consequently, many environmental impact studies are flawed and public hearings have been manipulated and politically driven to make money at all costs for the benefit of only a few.

All chapters of this book are well written and edited. They are well supported with references and are generally a great pleasure to read. The reader will appreciate the list of contributors, the list of abbreviations, annotated footnotes, and the detailed nine-page index, which turns this publication into a good reference source.

However, this high-profile book lacks any competence on Arctic biodiversity issues, as well as on online data portals, e.g., for the Barents Sea and Circumpolar. It must further be seen as an oversight on the editor's part that relevant island politics of Svalbard and Wrangel are virtually ignored! The same is true for Arctic shipping, Siberian wetland issues, and the otherwise prominent FSB/KGB and arms trade topics. But this book makes no mistake in the provision of facts about modern Russia and its politics. However, as the list of authors and funding shows (the oil and gas chapter, for instance, is funded by the Research Council of Norway directly!), the Norwegian texts and institutions are somewhat one-sided, do not go

about it in a balanced way, and do not promote a truly international Arctic.

Many relevant Russian references are not cited, e.g., F. Shilmark. Celebrating a western economically motivated view of Russia, as practised for centuries, is not necessarily a good objective or a healthy one. For instance, the folly of continuing to invest in the carbon industry in the year 2009 is not mentioned, and the role of China as a main player for Russia, for the Arctic and globally, is virtually not represented. The same can be said for tropical nations that are tightly linked to the poles through climate and resource questions. It gets rather annoying when the book does not mention Norway's bad role in global carbon pollution and climate change or that Norway has already overharvested some of its own fish stocks (as publicly recognized by the Conservation of Arctic Flora and Fauna, CAFF). Norway's treatment of indigenous people is not always appreciated by all stakeholders either.

The authors easily condemn the Russian (radio-active) pollution in the Kola region and the Barents Sea, but they are surprisingly quiet on the subject of whether traded Norwegian fish stocks are contaminated (a fact that is well documented in Polar Bears, for instance, which are an inherent part of the same Arctic food chain). Also, this book leaves out the peculiar fact that Norway does not support the EU but its approximately 4 million citizens benefit greatly from many aspects of the nearby EU market and EU funding schemes. Not surprisingly, I find that the dramatic problem of a ruthlessly applied economic growth

policy in the Arctic gets entirely ignored by the authors (it is suggested that the audience read Czech (2008), for instance).

I conclude that this book is helpful in understanding modern Russia, as well as the one-sided Norwegian Arctic, oil and gas and fisheries views, and the North overall. But together with books like Chaudhary et al. (2007), it just makes for one more Norwegian-biased publication that promotes strategic and one-sided western resource extraction views to a global audience which is not given all the facts to differentiate correctly, see all impacts, and understand the complete picture. Such attempts will not be helpful for building trust if all global citizens ought to live together peacefully and for sharing the global wealth for mutual benefit beyond the time when Norwegian oil and gas, fish, and related money run out, and when adjacent Russian resources and global influence as a military superpower will become even more dominant.

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#### MISCELLANEOUS

##### Arthur Carhart, Wilderness Prophet

By Tom Wolf. 2008. University Press of Colorado, 5589 Arapahoe Avenue., Suite 206C, Boulder, Colorado 80303 USA. 294 pages, 42.92 USD.

"The smartest landscape architect is the one who is clever enough to fit the use pattern deftly to the existing conditions with the least physical change needed to adapt site to use." So wrote Arthur Carhart in 1961 near the end of his career as a planner and landscape architect. His career began in 1917 with a Chicago landscape architectural firm, and he went on from there to become the first landscape architect in the US Forest Service (1919-1923). During this time he married and moved to Denver, Colorado, where he made his home for the rest of his life. He followed his formative years in a career as a wilderness writer with at least eight novels as well as many hunting and fishing guides over a period of 45 years. He also wrote numerous articles for magazines. His career embraced landscape, conservation, and recreation issues associated with the American forests. He was an advocate,

political activist, planner, and defender of wilderness land-use issues. He also gained popularity as a radio personality for about 15 years in the Denver area.

Carhart (1892-1978) lived in the unique time when the United States wilderness emerged from visits by aboriginal people, trappers, hunters, and pioneers to the time of vacationers travelling by automobile. One of his first projects and one which shaped his perspective throughout his career was a wilderness area assigned to him by the Forest Service at Trappers Lake, Colorado. Trappers Lake was an ancient Ute Native sacred site at the head of a watershed. Early unrestricted development had made its shores unsightly, and the limited water access made sewage pollution a problem as the number of visitors increased. Over a 30-year period, he studied, advocated for and developed detailed plans for the preservation and recreational



use of the lake. In 1983, a trail which bears his name was established on the site where his original plans have been implemented, largely unchanged.

Disillusioned, Carhart quit the Forest Service in 1923. As a writer, advocate and general curmudgeon working outside of government, he had few friends in official circles. But many not-for-profit advocacy groups enlisted him as their champion, and he responded generously from his personal ideals as well as developing and presenting ideas of viable alternatives to the *status quo* or official management plans. Often his writings were severely criticized, and his attempts to contact the directors of the Forest Service and the National Park Service or to work with both of them brought only animosity from internal bureaucratic kingdoms.

Due to his advocacy and refusal to compromise the zoning principles which he had developed over the years, his final battle was with the creation of the US Wilderness Act of 1964. Currently the definitive statement on land use and the provisions for recreation,

grazing, tree harvesting, and maintenance of wilderness "primitive" areas, this act was a political document directing wilderness areas to be identified and managed by both the Park Service and the Forest Service. Carhart finally stood by and refused to support the bill.

In his final battle, Carhart showed his stature as a wilderness architect and planner. He was always on the side of nature but included people in his view of how nature would unfold. The sites he identified and planned were for people to use, not simply to be left unvisited or unrestricted. Hunting and fishing were his passions, as were camping, growing flowers, and planting trees imported to beautify urban settings or to enhance natural forest regeneration. His home in Denver was a model of city planning and suburban fit to the landscape. His priorities for the wilderness were the same: use the existing conditions, alter the site minimally, and let all enjoy the effect.

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## Of a Feather: A Brief History of American Birding

By S. Weidensaul. 2007. Harcourt Inc., 6277 Sea Harbor Drive, Orlando, Florida 32887 USA. 358 pages, 24 USD Cloth.

Author Scott Weidensaul belongs to the field glass fraternity: obsessed with seeing birds, he is one of these "nerds with a binocular and an anorak". This book explains such birders to the lay person. It summarizes a great cultural phenomenon that has the potential to help us reach global sustainability. We currently experience nothing but the Golden Age of Birding. And imagine—birding is basically free and for everyone. This book covers in its 380 pages not only famous and tight-lipped "Ueberbirders" like R. T. Peterson but also the American history of birding (and its formative stages). Naming the book a "brief history" is somewhat of an understatement, though. This book is especially strong on the early history of ornithology (bird study). But ornithology is not birding, really, and it is here where the book blurs the lines somewhat and deviates from classic definitions.

The author does a good job showing that American birding and ornithology went through three phases: collecting (shotgun ornithology), maturing, and birding. The ongoing conflict in America between invasive ornithological collectors (Weidensaul states, for instance, that R. Beck personally collected some species to extinction) and non-invasive birders is well presented. This is demonstrated by C. B. Cory, a former president of the American Ornithologists' Union (AOU) who amassed over 19 000 bird skins and who argued strongly against the "Audubonians". As presented in this book, these organizations became some of the most prominent forces for birds in the US and thus shaped a new (global) bird and conservation culture that

helped to set the stage for benign bird studies that advance global sustainability.

Egg collection (leading to the discipline of oology) is another recurring theme in the history of (American) ornithology. The relevance and impact of this sometimes doubtful exercise become obvious when you realize that 30 000 eggs were collected by Arthur C. Bent alone (another former president of the AOU; the collection is now stored in the Smithsonian).

With America having "Birds more beautiful than in Europe" I liked the sections that showed the English influence on American ornithology and on birding. At least in its early days, the AOU (founded in 1883) followed the British Ornithologists' Union (founded in 1858) almost blindly. Settlers in America named species as they were used to from Europe and thus created a "nomenclatural mess". Traditional ornithological knowledge held by North American aboriginal people was virtually lost due to warfare and disease. Therefore, most North American bird accounts came from white (male) sources. The Spaniards left during their colonial rule virtually no bird accounts for Florida or the southwestern US. But the British—often land speculators—liked to present exotic birds to make the land more attractive. Famous representatives of this period are presented in this book: G. Percy (1606), F. Higginson (1629), and J. Lawson (1709). And Lewis's Woodpecker and Clark's Nutcracker remind us that M. Lewis and W. Clark started a flood of new bird discoveries from the western US, "almost all of them a result of military expeditions". The S. Long

expedition of 1819 across the southern plains to the Rockies in Colorado, with T. Peale as one of the first trained naturalists on such an expedition, helped further the descriptions of new avian features of this fascinating continent.

References to J. J. Audubon are certainly found all over the book, including L. Audubon's protégé, G. Bird Grinnell. But the reader learns that it was M. Catesby who actually put habitat features in bird paintings, way before Audubon did. We learn in this informative book that Catesby was also progressive enough for his time to reject the idea, still widespread in the 18th century, that migratory birds hibernated in caves or hollow trees or in the depths of the ocean. Further, we learn that many of the North American bird scholars also studied native culture. B. Bartram and J. Burroughs (one of the most influential nature writers of the late 19th century) are representatives of such concepts.

Later, O. Sewall Pettingill and J. Lane moved birding in the modern direction by publishing for the first time for the lay public where to find and see birds in the US. And so, the old-fashioned opera glass birding led to birding as a noun. "Increasing availability of European optics made it easier to see birds," and Peterson's *Field Guide to the Birds*, a "birding bible," became another tool in this movement. But Weidensaul shows us that there is more to this cultural phenomenon: Peterson's work built a lot on B. Hornbeck, L. Griscom (*Birds of New York City Region*), E. Thompson Seton, and B. Vogt, among others. F. Chapman had already published a first colour key to North American birds in 1903, and the guidebooks by C. Reed published three years later were a sensation.

Peterson's field guide book publications have actually been around since the late 1930s. But they were initially criticized, and it wasn't until 1947 that his concept (drawn little arrows pointing at the relevant field identification features, a copyrighted approach that is by now also used in entomology, botany, for fishes and elsewhere) became the birding standard. Other milestone references such as the ones from R. Pough (with paintings by D. Eckelberry), *The Golden Guide* by C. S. Robbins (with artwork by A. Singer), the Master Birding Guide and the one from the National Geographic Society (*Field Guide to the Birds of North America* of 1983) are well described, too, and put into wider context. Eventually, it all fell to D. Sibley to publish a milestone field guide book in 2000 (the fastest selling field guide in history). As shown by the infamous *Birds of Europe* from L. Jonsson, impressionistic gesture sketches of birds are usually stronger for field identification than photos. However, photo guides like the *National Audobon Society Field Guide to North American Birds* by J. Bull and J. Farrand, or the one by M. Udvardy, still became hits. Weidensaul elaborates with great expertise on special guidebooks from Britain and the US on gulls, seabirds, shorebirds, and hawks.

A well-founded criticism that Weidensaul makes is that birding is still a phenomenon of the white race. And, unfortunately, this peculiar outdoors activity can be inherently cliquey as well. American ornithology is very hierarchical, as can be seen in who trained and mentored whom; it's hard to break into these circles from outside. Weidensaul devotes a larger and overdue chapter, entitled "Angry Ladies," to the female contribution to birding. As late as 1982, the Nuttall Ornithological Club did not allow women to join! Imagine G. Lewis—author of the great book, *A Natural History of Birds*—being denied a job simply because of her gender.

Weidensaul also does a fine job showing that birding actually grew up in the urban corridor of the east coast and then matured in Florida, Texas, and Chicago. But it really came of age in California, a society and culture fuelled by oil. In this fascinating text, guerrilla birding comes to life again. This Californian birding craze promoted and lived by G. McCaskie and R. Stallcup caught on world-wide. Later, and together with C. J. Ralph, these birders started the infamous Point Reyes Bird Observatory. Where would American birding have gone in the last 50 years had McCaskie stayed in Great Britain? Further, we learn in this birding milestone book that J. Carter was an avid birder and that Pacific pelagic birding started with R. Beck, I. Gabrielson, T. Wahl, and D. Robinson (who later changed her name legally to D. Love Shearwater). The Atlantic coastal waters off Maine were similarly well covered by seabird enthusiasts such as M. Libby and W. Drury. I liked learning from this book that the famous D. Sibley was a "bird bum" for parts of his life and that he did not enjoy studying at university (a feature widely shared by many experienced naturalists, outdoor enthusiasts, and conservationists). Descriptive ornithology, where amateurs often excel, was already disappearing from academic journals back then, a sad disconnect found in "modern" biology departments world-wide. What a tragedy.

Despite "Roger Tory Peterson being the very personification of the tribe," neither his parents nor his teachers approved of the King Penguin (as he is widely known now) planning for a career in birding.

Weidensaul shows us that birders cater to their optical harem and are book addicts. Birders will also enjoy the description of *Birding* magazine and how it came to be. Detecting the "jizz" of a bird—its instantaneous impression—is crucial for its accurate identification in the field. The taxonomy of animals is still in flux; loons and Trail's Flycatcher (i.e., Willow Flycatcher or Alder Flycatcher) are examples of taxonomic toothaches. This list is easily expanded by the addition of Red-tailed Hawks with their many plumage varieties, the 18 recognized subspecies of Fox Sparrows, and the 24 to 39 distinguishable subspecies and up to 52 different forms of the Song Sparrow. I enjoyed reading about the pioneers of American sound record-



ings, A. Allen, P. P. Kellogg, and others, recording vanishing birds such as the Ivory-billed Woodpecker. But I fully agree with Weidensaul about sonograms basically being a waste of space in bird guides because one cannot interpret them meaningfully and they are hardly of help for species identification.

The phenomenon of listers occupies a wider section of the text. It was actually W. Stone, editor of *The Auk*, who publicized the idea of competition and listing in 1936: "Birding as a competitive pastime, one that places a premium on challenge." The sport of "binocular lifting" was born. Weidensaul describes in detail "Serious listing, the kind that empties bank accounts, ruins marriages, and borders on the pathologically compulsive." Many birders like to keep millennium lists (birds seen since 1 January 2001) or lists of birds seen but not photographed, for instance.

Flagship birders, super birders, such as T. Parker, S. Keith, K. Kaufmann, and J. Taylor, are described in detail as they reached the prominent 600 and 700 clubs (M. Smith is named as seeing 873 species; the initiation of the 900 Club is currently being discussed). I liked the way Weidensaul describes events like the Superbowl of Birding, held each year in Massachusetts, or the Big Birding Year with over 699 species (including its participants, such as K. Kaufman, F. Murdoch, J. Vardaman, and S. and A. Keith), or the World Series of Birding. Many adventures and cheating death several times aside, and before she actually died in a tragic car crash, P. Snetsinger probably saw the most birds in her lifetime world-wide. Her life list consisted of over 8000 birds. Another record holder is C. S. Robbins, who initiated the North American Breeding Bird Survey (BBS), now in its fifth decade. He also participated in over 350 Christmas Bird Counts, more than anyone else in history.

Historical oddities such as American economic ornithology and the acclimatisation movement are described in this unique book, which also mentions introduced starlings, mynahs, and House Sparrows. Cultural concepts in the history of bird studies, such as *Aves non grata*, e.g., raptors and wrens, and, when anthropomorphized, are elaborated on in the text, too. Citizen birds got labeled as good/bad and often were described as carrying an economic advantage for humans, so they were more easily accepted. Many early ornithologists (e.g., G. M. Sutton, G. Stratton-Porter) are reported to have fallen into this trap.

True conservation and its culture did not really emerge from the AOU itself, or from the society of experts, but from other groups and sources. And so Weidensaul states that birders have woefully neglected conservation issues: "Birders need to be more vocal on behalf of the things they care about" "in a world of burgeoning human population, diminishing natural habitat, changing climate, and shrinking resources." Scholars of environmental history will enjoy reading about R. Pough (who set up the Nature Conservancy)

or about R. Edge (one of the most important but somewhat overlooked forces in American conservation).

Eco-tourism and birding are actually not that new, as shown by Weidensaul when he refers to the Hawk Mountain Sanctuary already having thousands of weekend observers in the 1930s. Additional and similar birding sites and organizations are presented, such as the Manomet Bird Observatory (Manomet Conservation Science) and Point Reyes, where up to 490 bird species can be found, the highest diversity of birds in any North American national park. Another birding hotspot is the New Jersey Audubon's Cape May Bird Observatory, which has an impressive record of over 80 000 raptors, more than a million seabirds per year, 1.5 million shorebirds, and a quarter of a million passerines in fall at one site alone.

Birding is almost free of ideology in North America. That's good and bad. Was it big oil that moved birding in the UK towards world birding? And is birding in the U.S. basically left to the rich that can afford to enter the elusive club of 700 (birders that have seen more than 700 species)? They usually achieve this by traveling intensively. Seeing 700 bird species in North America is possible only if one includes vagrants, which can be found in higher numbers on the Mexican border and the Aleutian Islands. The Aleutian Islands, namely Attu and Adak, have attracted people obsessed with ornitho-golfing (the occurrence of nearby Eurasian birds boosts their lists).

But without birders, who would have known that the Saw-whet Owl was actually one of the most common raptors in North America? With the new notion of citizen science, birders take on the (monitoring) job that was originally meant to be a governmental one. Unfortunately, it is pushing government agencies into the convenient role of real estate, or project, agents that supervise without knowing. "Birding with a purpose" (cited from F. Hamerstrom) is for instance achieved in Project Feederwatch, started in 1976 in Ontario and now jointly managed by the Cornell Lab of Ornithology and Bird Studies Canada. Projects like Magpie Monitors are other examples. Discussion about conservation and non-governmental organizations such as the Audubon Society are not new, and the author presents "A Crisis in Conservation" by W. Van Name charging as early as 1929 that Audubon was being derelict in its responsibility to (water) birds. It was R. Edge and others who sued that organization successfully, creating bad press and a massive loss in membership.

I liked many of the conservation statements in the text, for instance, the struggles that K. Kaufman had when turning to conservation rather than just being a birder. No wonder that this is an issue for a country that caters to the biggest polluting industry of the world. Weidensaul promotes landscapes, protected zones, and wilderness well, but he could be even more forthcoming on this issue. He provides us with a nice

discussion of the taxation of outdoor gear in support of bird and habitat conservation. The Baillie Birdathon by Bird Studies Canada, initiated 30 years ago, has raised more than half a million dollars in Canada. But that's almost nothing when compared with the daily profits made by oil and other industries that usually get subsidized with large government grants of taxpayers' money.

What will the future of birding bring? Electronics has already brought large changes, giving us iPods, bird songs, and digital cameras at our fingertips, democratizing bird photography by making for good digiscoping via a telescope and telephoto lens. Phone-scoping provides additional confirmation of species. Birding in 2015 will probably see multimedia electronic field guides.

I liked the 24 informative black-and-white images and photos. And overall, I have nothing bad to say about this fine publication. Two things come to mind, though. For one, Weidensaul fails to mention the Cocker (2003) book or any relevant links with the large birding culture in the British world, namely in the UK and Australia, or in Heligoland and Scandinavia. This matters because an anthropological, cultural analysis of birding world-wide has still not been written. Second, Weidensaul does acknowledge that, without conservation, birding is a dead-end street. But, "For many birders, the sense of reciprocity, of obligation to the birds themselves, is missing". How true. What bothers me, though, is that Weidensaul does not expli-

citly deal with the core causes of (global) species and habitat loss, that is, the current economic scheme that constantly tries to sell us short-term solutions as the one and only paradigm. The American Congress can give the world almost anything money can buy. But it's typical that books like Weidensaul's stop at the rhetoric and leave us all puzzled about what to do next. Just buying shade-grown coffee is not enough, really, nor is counting birds in citizen science projects or, for instance, highly publicized outings like the Great Texas Birding Classic, where large corporate donations of over half a million dollars don't do us any good. Instead, by now, we need real action, revised policy, a justice system for nature (as promoted in Ecuador), and sound decision making. Unfortunately, I am not aware that birding data ever really stopped the development of large-scale industrial activities or that birding provided statistically sound data that held up in court for global sustainability. So it is here, beyond the description of the last subspecies—feather and feet coloration, including beak length and age classes—where Weidensaul and the birding community as a whole still need to provide us with real progress.

#### Literature Cited

Cocker, M. 2003. *Birders: Tales of a Tribe*. Visalia, California.

FALK HUETTMANN

EWHALE lab, Biology and Wildlife Department, Institute of Arctic Biology, 419 Irving I, University of Alaska, Fairbanks, Alaska, USA



## NEW TITLES

Prepared by Roy John

† Available for review \* Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

## ZOOLOGY

**All About Birds—A Short History of Ornithology.** By V. Chansigaud. 2010. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237. 240 pages. 29.95 USD Cloth.

**Audubon: Beyond Birds—Plant Portraits and Conservation Heritage of John James Audubon.** By E. Small, Paul M. Catling, J. Cayouette, and B. Brookes. 2009. NRC Research Press, National Research Council Canada, 1200 Montreal Road, Building M-55, Ottawa, Ontario K1A 0R6. 266 pages. 34.50 CAD.

\* **Bear Wrangler—Memoirs of an Alaskan Pioneer Biologist.** By W. Troyer. 2010. University of Chicago Press, 1427 East 60<sup>th</sup> Street, Chicago, Illinois 60637. 256 pages. 1995 USD Paper.

\* **Birds of Canada.** By D. Bird. 2010. Tourmaline Editions Inc. [DK Books], 662 King Street E., Suite 304, Toronto, Ontario M5V 1M7. 512 pages. 40.00 CAD Paper.

\* **Birds of Europe.** Second Edition. By Lars Svensson. 2010. Princeton University Press, 41 William Street, Princeton, New Jersey 08540. 416 pages. 29.95 USD Paper.

\* **Farmland Birds Across the World.** Edited by Wouter van der Weijden, Paul Terwan, and Adriaan Guldemond. 2010. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 144 pages. 24 EUR plus shipping Cloth.

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**A Field Guide to Squid and Octopods of the Eastern North Pacific and Bering Sea.** By E. Jorgensen. 2010. Alaska Sea Grant, 1007 W. 3<sup>rd</sup> Avenue, Suite 100, Anchorage, Alaska 99501. 100 pages. 25 USD Paper.

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## BOTANY

**Flora of China. Volume 25.** 2010. Missouri Botanical Garden Press, P.O. Box 299, St. Louis, Missouri 63166-0299. 125 USD Cloth.

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**The Complete Up North: A Guide to Ontario's Wilderness from Black Flies to the Northern Lights.** By Doug Bennet and Tim Tiner. 2010. McClelland & Stewart Ltd., 75 Sherbourne Street, 5<sup>th</sup> Floor, Toronto, Ontario M5A 2P9. 24.99 CAD. Paper.

\* **The Game of Conservation, International Treaties to Protect the World's Migratory Animals.** By Mark Cioc. 2010. Ohio University Press, 19 Circle Drive, The Ridges, Athens, Ohio 45701-2979. 232 pages. 49.85 USD Cloth.

**A Guide to Weather Forecasting.** By Storm Dunlop. 2008. Firefly Books. 176 pages. 19.95 CAD Paper.

\* **Innocents in the Dry Valleys—An Account of the Victoria University of Wellington Antarctic Expedition, 1958-59.** By Colin Bull. 2010. University of Alaska Press/ University of Chicago Press, 1427 East 60<sup>th</sup> Street Chicago, Illinois 60637. 267 pages. 25.00 USD Paper.

**Ladies in the Laboratory III.** By Mary R. S. Creese. 2010. Scarecrow Press, 4501 Forbes Boulevard, Suite 200, Lanham, Maryland 20706. 258 pages. 75.00 USD Cloth.

**The Practical Astronomer.** Tourmaline Editions Inc. [DK Books], 662 King Street E., Suite 304, Toronto, Ontario M5V 1M7. 256 pages. 22.95 CAD Paper.

## YOUNG NATURALISTS

**How Animals Work.** Tourmaline Editions Inc. [DK Books], 662 King Street E., Suite 304, Toronto, Ontario M5V 1M7. 192 pages. 28.99 CAD Cloth.

**Nature Explorer.** Tourmaline Editions Inc. [DK Books], 662 King Street E., Suite 304, Toronto, Ontario M5V 1M7. 256 pages. 16.95 CAD Paper.

## News and Comment

*Marine Turtle Newsletter*, Number 125, July 2009

ARTICLES: Flags Reduce Sea Turtle Nest Predation by Foxes in NE Brazil, *Guilherme O. Longo, Fernando D. Pazeto, João A. G. de Abreu, and Sergio R. Floeter* — Acclimating Captive Hawksbills to Sea Prior to Release, *Barbara Carr Whitman* — Inter-nesting Dive and Surface Behaviour of Green Turtles, *Chelonia mydas*, at Raine Island, Northern Great Barrier Reef, *I. P. Bell, J. Seymour, R. Fitzpatrick, and J. Hogarth* — Sea Turtles Tagging in Libya, *Abdulmaula Hamza, Al Mokhtar Saied, Bashir Swayeb, and Saleh Deryag* — Shifting Patterns of Nocturnal Emergence Events of Nesting Loggerhead Turtles (*Caretta caretta*) *Ryan Welsh and Anton D. Tucker*. NOTES: Foraging by a Gravid Green Turtle During the Internesting Interval in Guadeloupe, French West Indies, *Eric Delcroix, F. Leveque, J. Coudret, S. Bonotto, F. Créantor, M. Charrieau, and S. Guilloux* — A Leatherback Turtle Encountered in El Nido, Palawan, Philippines, *R. A.*

*F. Salinas, N. B. Ramoso Jr., and L. D. Rodriguez* — IUCN-MTSG Quarterly Report — Announcements — News and Legal Briefs — Recent Publications. *The Marine Turtle Newsletter* is edited by Lisa M. Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA; and Matthew H. Godfrey, NC Sea Turtle Project, North Carolina Wildlife Resources Commission, 1507 Ann Street, Beaufort, North Carolina 28516 USA. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael S. Coyne (Managing Editor), Marine Turtle Newsletter, A321 LSRC, Box 90328 Nicholas School of Environment and Earth Sciences, Duke University, Durham, North Carolina 27708-0328 USA; email: [mcoyne@seaturtle.org](mailto:mcoyne@seaturtle.org).



# Minutes of the 130<sup>th</sup> Annual Business Meeting of the Ottawa Field-Naturalists' Club 13 January 2009

Place and time: Canadian Museum of Nature, Ottawa, Ontario, 7:30 pm  
Chairperson: Ken Allison, President

Attendees spent the first half-hour reviewing the minutes of the previous meeting, the Treasurer's report and the Report of Council. The meeting was called to order at 7:55 pm with some opening remarks from the President.

## 1. Minutes of the Previous Meeting

It was moved by David Hobden and seconded by Diane Lepage that the minutes of the 129<sup>th</sup> Annual Business Meeting be accepted.

Carried

## 2. Business Arising from the Minutes

There was no business arising from the Minutes.

## 3. Communications Relating to the Annual Business Meeting

There were no communications relating to the Annual Business Meeting.

## 4. Treasurer's Report – Frank Pope

Frank began by acknowledging and thanking all of the many Club volunteers, our landlord The Central Experimental Farm, The Canadian Museum of Nature and Canadian tax payers (grants and tax reductions for donations to the Club).

Using 3 charts, he then presented a synopsis of financial activities in the fiscal year ending September 30, 2009.

Of note:

- the assets of the Club have been significantly enhanced in recent years by bequests;
- the recent stock market crash has not affected these assets;
- \$100,000 was donated to the Nature Conservancy of Canada towards the purchase of the Elbow Lake property, a pristine natural area in the Frontenac Arch formerly owned by Hewlett-Packard;
- approximately \$6500 was received in donations;
- the operating statements for the OFNC and of the CFN are now consolidated;
- in recent years the Club has been running an operating deficit which has been covered by interest and donations.

Frank then addressed the detail in a page by page review of the audited financial statements.

It was moved by Frank Pope that this financial statement be accepted as a fair representation of the financial position of the Club as of September 30 2008.

Seconded by Ann MacKenzie.

Carried

## 5. Committee Reports

Ken Allison asked for questions and comments on the Committee reports which had been distributed to the attendees. He thanked the committee chairs for submitting their reports in a timely fashion.

Moved by Frenja Brodo and seconded by Diane Lepage that the reports be accepted.

Carried

## 6. Nomination of the Auditor

Moved by Frank Pope and seconded by Connie Clark that Janet Gehr continue as Auditor for another year.

Carried

## 7. Report of the Nominating Committee – Frenja Brodo

SLATE PROPOSED BY THE NOMINATING COMMITTEE

### Officers

President	Ken Allison
1 <sup>st</sup> Vice President	Ann Mackenzie
2 <sup>nd</sup> Vice President	vacant
Recording Secretary	Annie Bélair
Treasurer	Frank Pope

### Ex-officio members

Past President	Michael Murphy
Administrator	(Frank Pope)
Editor CFN	Francis Cook
Editor T&L	Karen McLachlan Hamilton
ON Nature Rep	Diane Lepage

### Committee Chairs

Awards	Eleanor Zurbrigg
Birds	Chris Traynor
Conservation	Stan Rosenbaum
Education & Publicity	Gillian Marston
Excursions and Lectures	Fenja Brodo
Executive	(Ken Allison)
Fletcher Wildlife Garden	Sandra Garland
Finance	(Ann MacKenzie)
Macoun Club	see below
Membership	Henry Steger
Nominations	(Fenja Brodo)
Publications	Ron Bedford

*Members at large*

Barbara Chouinard

Julia Cipriani

David Hobden

Diane Kitching (Macoun)

Luke Periard

Jeff Skevington

*Chairs not on Council*

Macoun

Rob Lee

**New on the council:** Sandra Garland

Moved by Fenja Brodo and seconded by Frank Pope that the above slate be accepted as members of the Council of the OFNC for 2009.

**Carried****8. New Business**

There was no new business.

**9. Presentation**

Fenja Brodo presented a thank you gift to Marc Diotte in appreciation of his help with the audiovisual equipment during the OFNC meetings at the Museum.

**10. Adjournment**

Moved by Fenja Brodo and seconded by Connie Clark that the meeting be adjourned at 8:35 pm.

**Carried**

ANNIE BÉLAIR

Recording Secretary

**The Ottawa Field-Naturalists' Club Committee Reports for 2008****Birds Committee Annual Report To Council – October 2008**

The Birds Committee organized the Fall Bird Count 2008 and with the Club des Ornithologues de l'Outaouais participated in the operation of the Christmas Bird Count 2007. We also organized a successful Peregrine Falcon Watch at the nest sight in downtown Ottawa. The Bird Record Subcommittee continues to review rare bird reports and is now doing much of its work via the internet. Again this season, the seed-a-thon was successful in raising money to operate the club's bird feeders. A screech owl nest box program was initiated with the construction of 15 nest boxes. We continue to operate a rare bird alert and the Ottawa bird status line, a recorded telephone message of current bird sightings.

CHRIS TRAYNOR

Chair, Birds Committee, OFNC

**The Ottawa Field-Naturalists' Club Conservation Committee Annual Report for the Year 2008 – October 2008***Contribution to Nature Conservancy of Canada Purchase*

In consideration of recent bequests, the committee recommended that OFNC make a contribution towards the Conservancy's purchase of the 1,000-acre Elbow Lake property, for which the total amount required from non-government sources was approximately \$1,100,000. Council decided to contribute \$100,000.

*Larose Forest*

Christine Hanrahan represented OFNC on numerous meetings of the Prescott-Russell forest advisory committee as they considered the protection and development plan for the forest, among other things.

*Water Chestnut, Trapa Natans, in Voyageur Provincial Park*

Seven OFNC volunteers spent a total of 10 person-days assisting MNR staff at Voyageur Park, six of them working from canoes to remove the weed, and one on foot inspecting creeks within the park. The volunteers were recruited by means of an email message sent to OFNC members.

*Leitrim Wetlands Appeals*

An OFNC pledge of \$1,000 towards expert witness costs has been paid. The application by the Greenspace Alliance

(GA) and Sierra Club of Canada (SCC) for a judicial review was not successful, but the appeal of permits to take water (PTTW) has survived a preliminary motion for dismissal.

*City of Ottawa Greenbelt White Paper and Questionnaire*

An email was sent on September 8 to all OFNC members who gave an email address (about 350 addresses) inviting them to respond to the City of Ottawa's White Paper called "Development in the Greenbelt", and to let us know that they did this. A reminder was sent on Sep 22, and a thank-you note was sent on October 14. In all, 27 members informed us that they responded before the September 30th deadline. Committee members (Stan Rosenbaum, Ken Young, respectively) represented OFNC at the first two meetings of the Greenbelt Coalition, on July 24 and September 30.

Report submitted by Stan Rosenbaum, Chair.

**Education & Publicity – 2008 Annual Report**

The committee created another set of display panels for the large club display using Pollinators as the theme.

Committee members participated with displays at the National Wildlife Week's Wildlife Festival, DND during Environment Week, the EcoFair at the RA Centre, our second NAC Youth Orchestra concert, the OFNC Soiree and the Larose Forest day.

Once again the OFNC participated in the Ottawa Science Fair sponsoring a prize for a project co-judged by Jeff Skevington and Carolyn Callaghan.

The committee created a new booklet celebrating the Alfred Bog conservation achievement re-publishing the Don Cuddy T&L article from 1983 (25 years ago). A second booklet about the Larose Forest was also created. They include history, habitat descriptions and species checklists.

The committee also arranged speakers for outside groups.

The committee conducted a publicity outing to Mer Bleue with the portable club information display.

GILLIAN MARSTON

**Finance Committee Annual Report 2008**

The Finance Committee met twice during the year, March 10 and June 4 as well as internet communication throughout the year. Highlights include:



Donation of \$100,000 bequest funds to the Nature Conservancy to help finance the purchase of the Elbow Lake land in the Frontenac Arch.

Modifying the Funding Request Policy to require any funding requests outside the normal budgeting process to state if the funds are to be from operating or capital.

Changing the format of the Income Statement and budget to amalgamate the OFNC and the CFN.

Engaging a consultant to switch the financial accounting system to Simply Accounting starting in the 2008-09 fiscal year.

A proposed budget for 2008-2009 was developed and submitted to Council. A deficit of \$18,530 was forecast.

#### **Fletcher Wildlife Garden – Annual Report for 2007-2008**

This year was again successful for the Fletcher Wildlife Garden. Volunteers contributed over 3600 hours, working in groups on Friday morning and Wednesday evening. A significant sized section of the Butterfly meadow was roto-tilled and re-planted with native species. The control of invasive species, namely pale swallowwort, continued. The Woodland Walk In the Backyard Garden was re-vitalized. Several older directional and descriptive signs were replaced and some new signs were erected to encourage visitors to stay on designated paths and out of the ravine. Approximately 70 new bird, butterfly and insect species were found.

FWG was used for Club and non-club events, for example, workshops on pollinators and invasive species, and walks including the FWG annual International Migratory Bird Day walk, the Annual Butterfly Count and the walk for 48 Health Canada employees as part of Environment Week. Other school, scout, student and corporate groups came for volunteer work or educational activities. Also, advice on native-plant gardening practices was provided on request to four school-related and other public organizations. Our weed wrenches were lent to three external groups to remove buckthorn.

Annual Plant Sale revenue was over \$2000; donations exceeded \$500. HRSD provided a reduced grant but together with a generous contribution from the OFNC, we employed a summer student for 14 weeks. As well as the usual tasks such as operating the Interpretation Centre, receiving visitors, etc., the student was specifically charged with taking photographs of insects on plants in the Backyard Garden and taking water temperature, pH, dissolved oxygen, nitrate and phosphate measurements in three sites in the Amphibian Pond. A report is available. The instruments and supplies for carrying out these measurements were made possible by a City of Ottawa grant.

A contractor was hired with a City of Ottawa grant to remove the larger buckthorn trees in the ravine August 11 – 14<sup>th</sup>. Several trees and shrubs have since been planted to infill the site.

Approximately 30 friends and family attended the dedication of the Pergola to celebrate the life of Eileen Evans on April 26<sup>th</sup>. OFNC President Ken Allison offered a few words on behalf of the Club.

A computerized database of bird, mammal, insect, butterfly and reptile/amphibian observations recorded at FWG was implemented. Observations taken since 1990 (1967 total) have been entered.

Our web site (<http://www.ofnc.ca/fletcher.php>) remains very popular. The new Phase galleries which show photos of insects as well as those of bugs, beetles, butterflies, etc. found at FWG have been well received. Three issues of the "What's

Up at the Fletcher Wildlife Garden" email Newsletter were sent to subscribers.

HENRY STEGER  
Chair, Fletcher Wildlife Committee

#### **Macoun Club Committee Report for 2008**

The Committee met just once at the beginning of the year to set the Club's overall direction, with the month-to-month planning being handled by telephone and e-mail. Committee members supervised or gave presentations at 18 indoor meetings, and led 18 field trips. All meetings were held in the Fletcher Wildlife Garden building (rather than the Museum of Nature, which is under renovation).

The Macoun Field Club completed its 60th year without any special celebration.

For four years now there have been no high-school-aged members, but both younger age groups are strong. The older group was taken on a camping trip at Mary Stuart's old property, re-establishing a tradition that dates back 40 years.

The Club produces a monthly newsletter, an annual publication (The Little Bear) and maintains a website that is linked to the OFNC site. Additionally, the Macoun Club's group notebook on sightings in the Club's nature-study area in the Greenbelt near Bells Corners is being bound in hard-cover each year, and distributed to members.

ROBERT E. LEE  
Chairman, Macoun Field Club

#### **Membership Committee Annual Report for 2007-2008**

The distribution of the membership for 2008 is shown in the table (below), with the corresponding numbers for 2009 in brackets. "Others" represent, for the greatest part, affiliate organizations that receive complimentary copies of the Club's publications. Local membership (within 50 km of Parliament Hill) was 651 and 649 in 2007 and 2008, respectively. The reduction of 18 in total membership is a continuing challenge to the Club.

H. STEGER

#### **Excursions and Lectures Committee Annual Report for 2008**

In 2008 we arranged 32 trips and seven work shops (25 and 4 respectively last year) as well as ten monthly meetings and our annual Soirée. Of the trips, ten were all-day excursions and these were very successful and generally drew quite a crowd. Altogether we offered twelve birding trips, five of general interest, and other trips focussed on plants, slime molds, butterflies, mammals, fossils and local history. This was the second year that we participated in the North American Butterfly Count, preceded by a Skipper Workshop. Other workshops included keeping-the-heat-in, pollination, algae, and three on geology. Most were well-subscribed. The algal workshop was held at the CMN, all the others were at the Fletcher.

Our monthly Tuesday meetings are still being held in the Discovery Centre, 4<sup>th</sup> Floor, CMN while renovations are going on. We fill the space nicely but there seems to be an unavoidable slight lateral distortion of each photo due to the equipment available. (People and birds look fatter than they are.) Another problem that we had was finding out too late that preserved specimens (bats in this case) must be frozen at the CMN facility for several days before being allowed into the Museum (a pest control measure), but our speaker

	CANADIAN	USA	OTHER	TOTAL
Individual	396 (398)	16 (17)	3 (3)	415 (418)
Family	295 (312)	1 (1)	1 (2)	297 (315)
Sustaining	16 (15)	0 (0)	0 (0)	16 (15)
T and L	3 (2)	0 (0)	0 (0)	3 (2)
Honorary	21 (23)	0 (0)	0 (0)	21 (23)
Life	47 (42)	5 (6)	1 (1)	53 (49)
Other	26 (27)	1 (1)	1 (1)	28 (29)
TOTAL	804 819	23 (25)	6 (7)	833 (851)

was able to change focus and present a quite different talk on very short notice. Our meetings are very much enhanced by having hot drinks and cookies and by the activities at the sale table brought in by members of the Education and Publicity Committee.

The Soirée drew a good crowd (still room for more participants). Our auction was somewhat livelier this year and we earned the Club over \$300.

We wish to thank the many wonderful people who lead trips, present talks or help in the organization of all Club events.

Respectfully submitted,

FENJA BRODO

Chair, Excursions & Lectures Committee

5. Last year, Sandra Garland prepared an online nomination form that can be submitted directly to the Awards Committee Chair. This easy-to-use form elegantly completes the Awards page on the OFNC website. So far, however, no Club member has used the webpage form, but we hope that it will be used as more people notice its existence.

6. Irwin Brodo will be stepping down as Chair of the committee after eight years in that post and will be replaced by Eleanor Zurbrigg.

Respectfully submitted,

IRWIN M. BRODO, CHAIR.

4 December 2008

#### 2008 Annual Report – Awards Committee

1. The Awards Committee met January 17, 2008, to consider nominees for the OFNC awards. There were few nominations from the general membership, but the committee had no trouble in finding good candidates for all categories, except Honorary Member.

2. The award winners were as follows:

**Member of the Year:** Carla Hilado;

**George McGee Service Award:** Louis Larivée;

**Conservation Award – Members:** Erwin Dreessen;

**Conservation Award – Non-Members:** Cliff Bennett;

**Ann Hanes Natural History Award:** Ross Layberry;

**Mary Stuart Education Award:** Martha Webber.

3. Awards (as framed certificates) were handed out by Irwin Brodo and Ken Allison at the Annual Soirée held April 26, 2008. In addition to the certificates, a trophy was presented to Louis Larivée, the winner of the George McGee Service Award for the coming year, and a painting of a butterfly was given to Ross Layberry, winner of the Ann Hanes Natural History Award (purchased with funds from the Ann Hanes bequest).

4. Articles on the award winners were prepared by IMB for *Trail & Landscape* and for the *Canadian Field-Naturalist*.

#### Annual Report of The Publications Committee – 2008

The Publications Committee met only once in 2008. This was largely due to the Chairman's being unable to drive from about mid-summer. With luck, this problem will be resolved soon.

Four issues of *The Canadian Field-Naturalist* were published in 2008: Volume 120 (4) and Volume 121 (1,2, and 3). These four issues contained 486 pages; 48 articles; 19 notes; 62 book reviews; about 250 new titles; 1 commemorative tribute; 22 pages of News and Comment; 4 pages of miscellany; and a 21 page index. In the first three of the above issues, 8 papers were supported with Manning fund interest for a total of \$4151. Tests of an electronic version of *The Canadian Field-Naturalist* are on-going. Consideration is being given to using a more environmentally-friendly paper for *The Canadian Field-Naturalist* if certain necessary criteria are met (cost, archival longevity, quality).

Volume 42 of *Trail & Landscape* was published in four issues containing 212 pages. The 20-year index for Volumes 21 – 40, 1987 – 2006 has been prepared and appears on the Club website. It is also available on a CD for a small fee (probably about \$3.00). Hard copies will be available to those who wish it for a fee that covers the cost of printing.

Respectfully submitted,

RONALD E. BEDFORD

Chairman, Publications Committee



## Auditor's Report

To The Members of THE OTTAWA FIELD NATURALISTS' CLUB

I have audited the statement of financial position of THE OTTAWA FIELD-NATURALISTS' CLUB as at September 30, 2008, the statement of changes in net assets, the statement of operations, and the statement of cash flows for the year then ended. These financial statements are the responsibility of the organization's management. My responsibility is to express an opinion on these financial statements based on my audit.

Except as explained in the following paragraph, I conducted my audit in accordance with Canadian generally accepted auditing standards. Those standards require that I plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In common with many non-profit organizations, THE OTTAWA FIELD-NATURALISTS' CLUB derives some of its revenue from donations and fund-raising activities. These revenues are not readily susceptible to complete audit verification. Accordingly, my verification of these revenues was limited to the amounts recorded in the records of THE OTTAWA FIELD-NATURALISTS' CLUB, and I was not able to determine whether any adjustments to the recorded amounts might be necessary.

In my opinion, except for the effects of adjustments, if any, which I might have determined to be necessary had I been able to satisfy myself concerning the completeness of the revenue referred to in the preceding paragraph, these financial statements present fairly, in all material respects, the financial position of the organization as at September 30, 2008, and the results of its operations and cash flows for the year then ended in accordance with Canadian generally accepted accounting principles.

JANET M. GEHR

C.A., Licensed Public Accountant

North Gower, ON  
January 10, 2009

### The Ottawa Field-Naturalists' Club Balance Sheet September 30, 2008

	2008	2007
<b>ASSETS</b>		
CURRENT		
Cash	\$35,571	\$51,190
Investment certificate (Note 1)	140,688	196,498
Marketable securities (Note 2)	19,992	0
Accounts receivable	17,815	7,937
	<u>214,066</u>	<u>255,625</u>
LAND - ALFRED BOG (At cost, assessed value \$19,100)	3,348	3,348
Marketable Securities (Note 2)	<u>306,308</u>	<u>328,725</u>
	<u>\$523,722</u>	<u>\$587,698</u>
<b>LIABILITIES AND FUND BALANCES</b>		
CURRENT		
Accounts payable and accrued liabilities	\$4,684	\$3,096
Deferred revenue	12,901	7,335
	<u>17,585</u>	<u>10,431</u>
LIFE MEMBERSHIPS	<u>16,876</u>	<u>15,011</u>
NET ASSETS		
Unrestricted	248,084	320,218
Club reserve	100,000	100,000
Manning principal	121,827	122,441
Seedathon	690	46
Anne Hanes memorial	746	788
de Kiriline-Lawrence	12,733	13,603
Macoun Baillie Birdathon	1,204	1,183
Alfred Bog	3,977	3,977
	<u>489,261</u>	<u>562,256</u>
	<u>\$523,722</u>	<u>\$587,698</u>

**The Ottawa Field-Naturalists' Club**  
**Statement of Operations**  
**For the year ended September 30, 2008**

	2008	2007
<b>REVENUE</b>		
Memberships	\$24,554	\$24,418
Trail and Landscape	174	99
Interest	17,480	13,131
GST rebate	4,038	3,937
Sales	3,302	898
Other	200	325
	<u>49,748</u>	<u>42,808</u>
<b>OPERATING EXPENSES</b>		
Administrator	2,000	2,000
Affiliation fees	1,060	225
Website maintenance	2,252	2,406
Membership committee	1,060	1,185
Bookkeeper	6,300	6,300
Telephone	1,874	2,115
Insurance	694	725
Office	627	1,368
Postage	226	40
Professional fees	2,000	2,000
GST	4,343	4,748
Other	3,206	2,044
	<u>25,642</u>	<u>25,156</u>
<b>CLUB ACTIVITY EXPENSES</b>		
Awards	455	(60)
Birds	1,023	849
Canadian Field Naturalist (Note 3)	8,581	20,936
Conservation	0	12
Education and publicity	1,153	2,714
Excursions and lectures	(708)	(1,187)
Macoun Field Club	416	546
Trail and Landscape	10,815	10,457
Fletcher Wildlife Garden (Note 4)	3,419	410
	<u>25,154</u>	<u>34,677</u>
<b>EXCESS EXPENSES</b>	<u>(\$1,048)</u>	<u>(\$17,025)</u>

**The Ottawa Field-Naturalists' Club**  
**Statement of Cash Flows**  
**For the year ended September 30, 2008**

	2008	2007
<b>Cash Flows from Operating Activities</b>		
Excess (expenditures) revenue for the year	(\$1,048)	(\$17,025)
Net change in non-cash balances	<u>(15,612)</u>	<u>19,797</u>
<b>(Decrease) in Cash from Operating Activities</b>	<u>(16,660)</u>	<u>2,772</u>
<b>Cash Flows From Financing and Investing Activities</b>		
Contributions of cash from endowments	34,500	181,226
Contributions of cash from donations and fund raising	13,568	16,819
Increase in Life Memberships	1,865	932
Cash used for fund activities	(107,127)	(13,649)
Net purchase and sale of investments	<u>2,425</u>	<u>17,963</u>
	<u>(54,769)</u>	<u>203,291</u>
<b>Net (Decrease) Increase in Cash and GIC</b>	<u>(71,429)</u>	<u>206,063</u>
<b>Cash and GIC, beginning of year</b>	<u>247,688</u>	<u>41,625</u>
<b>Cash and GIC, end of year</b>	<u>\$176,259</u>	<u>\$247,688</u>
<b>Net Change in Non-Cash Balances</b>		
Accounts receivable	(\$9,878)	\$23,554
Cumulative unrealized losses on financial assets	(12,888)	0
Accounts payable and accrued liabilities	1,588	596
Deferred revenue	<u>5,566</u>	<u>(4,353)</u>
	<u>(\$15,612)</u>	<u>\$19,797</u>



**The Ottawa Field-Naturalists' Club Notes to the Financial Statements**  
**For the year ended September 30, 2008**

	2008	2007
<b>3. Canadian Field Naturalist Operations</b>		
REVENUE		
Subscriptions	\$21,483	\$9,275
Reprints	2,909	3,721
Publication charges	36,419	19,831
Other	2,178	1,458
	<u>62,989</u>	<u>34,285</u>
EXPENSES		
Publishing	44,731	36,061
Reprints	1,940	1,900
Circulation	9,402	7,156
Editing	15,365	9,694
Other	132	410
	<u>71,570</u>	<u>55,221</u>
<b>Excess Expenses Over Revenue</b>	<u>(\$8,581)</u>	<u>(20,936)</u>
<b>4. Fletcher Wildlife Garden</b>		
	<b>2008</b>	<b>2007</b>
REVENUE		
Human Resources and Skills Dev. Canada	\$1,838	\$4,545
City of Ottawa, water testing	1,125	0
City of Ottawa, buckthorn removal	7,875	0
Sales and other income	2,714	2,960
GST refund	119	176
Donations	1,135	3,700
	<u>14,806</u>	<u>11,381</u>
EXPENSES		
Program	5,385	4,412
Backyard	530	1,075
Buckthorn removal	7,800	0
Habitats	1,857	1,976
Interpretation centre	219	3,154
Administration	461	487
GST	550	210
Fund raising	212	0
Publications	46	205
Pond testing	1,140	0
Library	25	272
	<u>18,225</u>	<u>11,791</u>
<b>Excess Expenses Over Revenue</b>	<u>(\$3,419)</u>	<u>(\$410)</u>

**The Ottawa Field-Naturalists' Club Statement of Changes in Net Assets  
For the Year Ended September 31, 2008 (Note 5 for footnotes)**

Net Assets	Beginning Balance	Excess Expenses CFN	Excess Expenses OFNC	Other Revenue	Other Expenses	Ending Balance
Unrestricted	\$320,218	(\$1,048)	41,802 a)	(100,000) b)	(\$12,888) c)	\$248,084
Club reserve	100,000	0	0	0	0	100,000
Manning Principal	122,441	0	4,668	(5,282) d)	0	121,827
Seedathon	46	0	1,413	(769) e)	0	690
Anne Hanes Memorial	788	0	0	(42)	0	746
de Kiriline-Lawrence	13,603	0	130	(1,000) f)	0	12,733
Macoun Baillie Birdathon	1,183	0	55	(34)	0	1,204
Alfred Bog	3,977	0	0	0	0	3,977
	\$562,256	(\$1,048)	\$48,068	(\$107,127)	(\$12,888)	\$489,261

**The Ottawa Field-Naturalists' Club Summary of Significant Accounting Policies**

**September 30, 2008**

**1. Nature of Business**

The organization is non-profit and incorporated under the laws of Ontario (1884). The organization promotes the appreciation, preservation, and conservation of Canada's natural heritage. It encourages investigation and publishes the results of the research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with other organizations engaging in preserving, maintaining or restoring environments of high quality for living things.

**2. Financial Instruments**

On October 1, 2007 the Club adopted the new recommendations of the Canadian Institute of Chartered Accountants concerning financial instruments. This has require the Club to remeasure the financial assets and liabilities at the beginning of the fiscal year. Any adjustment of the previous carrying amount is recognized as an adjustment of the balance of net assets at the beginning of the fiscal year of initial application. The previous years financial statements have not been restated. Adoption of recommendation has had the following impacts on the classification and measurement of the Club's financial instruments:

Cash and short term investment certificates is classified as a held-for-trading financial asset, measured at fair value and changes in fair value are recognized in the statement of operations. There was no impact on the financial statements as at September 30, 2008.

Trade accounts receivable are classified as loans and receivables, and measured at amortized cost. In this case the value is at the same amount as originally recorded. There was no impact on the financial statements as at September 30, 2008.

Marketable securities and investments are classified as available-for-sale investments. They are recognized at fair value and changes in this value are recognized in the statement of changes in net assets until they are sold. On September 30, 2007 the fair value and the carrying amount of the investments were \$328,608 and \$328,725 respectively, resulting

in a decrease of the investments of \$117. On September 30, 2008 the fair value and the carrying value were \$326,300 and \$313,529, resulting in a decrease of \$12,771.

Accounts payable and accrued liabilities are classified as other financial liabilities. They are measured at amortized cost using the effective interest method. There was no impact on the financial statements as at September 30, 2008.

**3. Financial risk management objectives and policies**

The Club is exposed to various financial risks resulting from both it's operations and it's investment activities. The Club's management manages financial risks and focuses on actively guaranteeing the Club's short and medium term cash flows by minimizing its exposure to capital markets.

The carrying amount of the Club's financial assets on the statement of financial position represents the maximum amount exposed to credit risk. This credit risk is primarily attributed to the accounts receivable. The Club does not require a credit check or guarantee from its members. The accounts receivable are limited to small transactions for memberships and subscriptions, with the occasional larger one for articles.

**4. Capital Assets**

Capital assets in excess of \$4,000 cost are recorded as assets at cost and amortized on a straight-line basis. These assets have been fully amortized.

**5. Revenue Recognition**

Revenue is recognized when earned except for donations and fund-raising, which is recognized when received.

**6. Foreign Currency**

Transactions during the year in US dollars have been converted in the accounts to Canadian dollars at the exchange rate effective at the date of the transaction. All monetary assets in US dollars at year end have been converted to Canadian dollars at the rate effective on Sept. 30, 2008. Gains or losses resulting therefrom are included in revenue or expenses.

**7. Comparative figures**

Certain comparative figures have been reclassified to conform with the presentation adopted in the current year.



# Bias in American Ornithologists' Union Bird Names

PAUL F. J. EAGLES<sup>1</sup> and HECTOR CEBALLOS-LASCURAIN<sup>2</sup>

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Eagles, Paul F. J., and Hector Ceballos-Lascurain. 2009. Bias in American Ornithologists' Union bird names. *Canadian Field-Naturalist* 123(3): 295–298.

Ornithology has developed bodies to make collective decisions on the taxonomy, scientific names, and common names of birds. This tradition within ornithology assists with communication and reduces confusion. For North and Central America, a committee of the American Ornithologists' Union standardizes the taxonomy and nomenclature of all the birds that naturally occur within that area. This paper makes the point that this activity has been dominated by members from the United States, with insufficient attention paid to the appropriate use of the term "American" or to the concerns of citizens of countries other than the USA. As a result, the term "American" is used inappropriately as a synonym for North American in a geographic distribution sense. In addition, the terms "Canadian" and "Mexican" are used very sparingly or not at all in the English common name for species that occur in those countries. Suggestions are made with regards to the membership of the nomenclature committee and for remedying this problem with English common names.

**Key Words:** ornithology, taxonomy, birds, nomenclature, Canada, Mexico, United States of America, American Ornithologists' Union, Committee on Classification and Nomenclature of North and Middle American Birds, North American Classification Committee, AOU Check-list.

Ornithology has developed bodies to make collective decisions on the taxonomy, scientific names, and English common names of birds. This tradition within ornithology assists with communication and reduces confusion.

The American Ornithologists' Union (AOU) has standardized the taxonomy and nomenclature of the avifauna of North and Central America for many years. The Clements Checklist attempts to compile a global list of bird species. In the process it also uses English common names (Clements 2007). The British Ornithologists' Union (BOU), through the Taxonomic Subcommittee of the Records Committee, advises on all taxonomic and nomenclature issues of birds that have occurred in Britain and its seas. However, a major change occurred in 1998 when the BOU stopped publishing records from Ireland. This action took into account the sensibilities of the Irish, who objected to having Ireland labelled as part of Britain, as occurred when Irish records were published within the "British" list (Dudley et al. 2006). Birds Australia uses the Christidis and Boles checklist (Christidis and Boles 1994, 2008) as the basis for the birds of Australian lands and water. The Australian movement to develop a national decision-making structure partially came about because of concerns that foreign ornithologists, more specifically those who were British, were not in a proper position to understand and determine the taxonomy and nomenclature of Australian avifauna. Both of the British and Australian bodies have successfully dealt with nationalistic issues concerning bird checklists and naming.

One of the issues involved in decisions concerning taxonomy and nomenclature is the appropriate consideration and involvement of those affected. This paper argues that the American Ornithologists' Union has undertaken this work without a full understanding of the implications of the geographical wording, which includes an overemphasis on the use of the adjective "American" as a geographic range descriptor to name birds that range over areas much broader than the USA. It also includes a paucity of the use of the adjective "Canadian" or "Mexican" for species that occur in those countries. Suggestions are made both for revising the names of the birds and for creating a more inclusive body and approach to the decision-making process.

## Background

For North American birds, there is a useful tradition of standardizing the taxonomy and nomenclature, including common and scientific names of birds. This is often not done for other biota, such as plants, leading to confusion.

A problem in North and Central America is that the standardization of bird names has been done without full recognition of the political or geographical realities of the continent. This has led to a distorted view of bird distribution and a bias in the names across the entire continent and hemisphere. This has been an irritant to many for some time. This short paper outlines the concerns.

Founded in 1883, the American Ornithologists' Union is the oldest and largest organization in the

New World devoted to the scientific study of birds. The AOU is the "preeminent scientific ornithological society in this hemisphere" (Kricher 2008, page 32). The AOU *Check-list of North American Birds* is the accepted authority for bird names in the English language and scientific nomenclature for species that occur in one geographical area. The Committee on Classification and Nomenclature of North and Middle American Birds (known as the North American Classification Committee or NACC) is an official committee of the American Ornithologists' Union. The mandate of this committee is to keep abreast of the systematics and distribution of the birds in North and Central America, with the purpose of creating a standard classification and nomenclature. NACC produces editions of the *Check-list of North American Birds* as well as annual supplements published in *The Auk*. The North American Classification Committee is the decision-making body of the AOU for all matters relating to the North American checklist, including names. It is important to note that the North American checklist since 1983 has included all of Central America and adjacent islands, but excluded Greenland. The AOU maintains that the 7<sup>th</sup> edition of the AOU *Checklist of North American Birds* is the official source on the taxonomy of birds found in North and Middle America, including adjacent islands (AOU 2009\*). The checklist contains names in English. A French version is also available, but only with the 7<sup>th</sup> checklist. Apparently, no Spanish version has been done.

Scientific names follow priority of naming according to the earliest date of publication (starting with the 10<sup>th</sup> edition of *Systema Naturae* by Linnaeus, 1758). These are not subject to change, unless for taxonomic redefinition. However, common names are subject to change and are the primary focus of this article.

The membership of the AOU North American Classification Committee has always been strongly dominated by residents of the USA. For example, the committee that prepared the 49<sup>th</sup> supplement to the AOU checklist had 11 members; 10 of them were American and one was Canadian (Banks et al. 2008). No Mexican has ever been included. No members of other countries in the western hemisphere or Central America were included, even though with the 6<sup>th</sup> checklist the coverage expanded to all of North America and Central America.

It is important to note that the American Ornithologists' Union is not the North American Ornithologists' Union, nor is it the Ornithological Union of the Americas.

### American and America

The word "America" has an old and interesting history. In 1507, the German cartographer Martin Waldseemüller published a world map, *Cosmographiae introductio*, which ascribed the name *Americus* to the new world. The name came from the Italian Amerigo Vespucci (1454–1512), who had made two trips to

the northern and eastern coasts of what is now South America as a navigator. He published two works, in 1502 and 1504, that put forward the idea that this area was a new continent, not Asia. He was the first to call this area *Novus Mundus*, the New World (Catholic Online Encyclopedia 2007\*). This phrase took root and is still used. The word *Americus* became the standard, largely due to the German map using this name for the entire new world from the Arctic to the Antarctic. Some works say that *Amerigo* was used because it was more easily Latinized than *Vespucci* (Online Etymology Dictionary 2010).

The word "America" was used when some of the colonies of Great Britain broke away to form a new country and needed a name; they created the name the United States of America. Many other British colonies did not break away at that time, and today several countries, including Canada, Belize, and Bermuda, can trace their origins back to British colonies. A better name for the USA would probably have been the United States of North America (but even this name is confusing, as Mexico is also part of North America), but the shorter name was used. This country is now variously known as the USA, the US, the States, or America. There is another United States in North America, the United States of Mexico, with the official name Estados Unidos Mexicanos. However, it is almost always described by Americans and Canadians as Mexico, and seldom as the United States, or the States. The plural of America, "the Americas", is typically used to describe the combination of North America, Central America, and South America.

People who live in the USA developed a double meaning for the word "American." It is used primarily an adjective to describe a people, in a nationalistic sense. It describes people or objects being from or about the USA, as in the American flag or the American constitution. When a person is described as an American, it almost always means a citizen of the USA.

A secondary meaning of "American" is a location in the Americas. Let us give examples of the second meaning. In the science magazine *Discovery*, published in the USA, there was a story about a geologist reporting that a comet had exploded 13 000 years ago "just north of the Great Lakes" (Abrams 2008, page 60). However, the heading to the story was "Stone-Age Asteroid May Have Wiped out Life in America." So, according to this particular article, all the area north of the Great Lakes, which is entirely in Canada, is part of America. As another example, in the *Atlas of Bird Migration* (Elphick 2007), there is the following statement: "Uniquely American, the vireos are a group of some 46 foliage-gleaning forest birds..." (page 72). According to this American author, the vireos, which occur throughout most of North and South America, are called "American." Using this logic, all the birds and all the citizens of all countries in the Americas could be called American.



It is our basic proposition that the naming of bird species by the AOU involves an inadvertent "colonization" of bird nomenclature by the citizens of one country as part of an attempt to represent the entire continent without properly consulting the citizens of the entire affected area. According to the Oxford English Dictionary, colonialism involves the exploitation of the weak by a stronger power. The power of AOU NACC has allowed ornithologists from the AOU to "colonize" the English bird names of species to reflect a nationalistic American bias. Let us illustrate those names.

There are 21 bird species with the name "American" in the common name. It is our argument that it might make geographical sense to call these 21 American if each had the majority of its breeding range in the USA, but this is not the case. For example, several of these species have the majority of their breeding range in Canada, with American Black Duck and American Golden-Plover prime examples. Should not these species more properly be called the Canadian Black Duck and the Canadian Golden-Plover, if their breeding range is the reason for the adjective descriptor?

There are 16 species with *americana* or *americanus* in the species name on the North American list, and an additional 2 on the South American list, *Rhea americana* and *Sporophilla americana*—for a combined total of 18. Of these, *Siphonorhis americanus* (Jamaican Pauraque), has been extinct since 1859, but it is included in the AOU Checklist, and *Ibycter americanus* (Red-throated Caracara) exists from extreme southern Mexico (although it hasn't been reported there in the last several decades) to Brazil. Two of these 14 species have "American" in the common name, American Wigeon (*Anas americana*) and American Coot (*Fulica americana*). The vast majority of the breeding range of the American Wigeon is in Canada, while about half of the breeding range of the American Coot is in Canada. The name *americana/americanus* is not used accurately to describe the geographic range of these species, since most of the range is outside of the United States of America.

### Canadian and Canada

Even though there are 21 bird species with "American" in the common name in the North American list, there are no species of birds with "Canadian" in the common name. But there are two species with "Canada" in the common name, Canada Goose and Canada Warbler. If one were seeking consistency with the geographic sense of the use of the words and proper usage of "American" and "Mexican", these birds should be labelled Canadian Goose and Canadian Warbler. But this point of inconsistency in terminology is secondary to our major thesis.

There are eight species of birds with *canadensis* in the species name, in the combined North American and South American list, with seven in the North American

check-list: *Branta canadensis*, *Falcipecten canadensis*, *Grus canadensis*, *Perisoreus canadensis*, *Sitta canadensis*, *Wilsonia canadensis*, and *Caryothraustes canadensis*. None of these has "Canadian" in the common name, but two have "Canada" in the common name. In the North American and South American lists, we have two erroneous toponyms: *Sakesphorus canadensis* (Black-crested Antshrike) and *Caryothraustes canadensis* (Yellow-green Grosbeak). Both of these are South American birds, which have never been near to Canada in the wild. Apparently, in both cases the name *cayennensis* (after Cayenne or French Guiana) was intended (Jobling 1991).

To some Canadians, the most egregious naming by the AOU NACC is that of Gray Jay (*Perisoreus canadensis*). This species is found in the boreal forest from Newfoundland to the Yukon, with a part of its range in Alaska and in the western mountains of the USA. It was known for years as the Canada Jay until the AOU NACC changed the name to Gray Jay. This was a very strange name change, since the vast majority of the species' entire range, both breeding and wintering, is in Canada, and the scientific name is *canadensis*. The closely related species in Eurasia is the Siberian Jay (*Perisoreus infaustus*). That species is found in boreal habitat from Norway to western Siberia. In this Eurasian species, the English common name, Siberian Jay, is a good descriptor of its breeding and overall range—Siberia. Therefore, this species should be called the Canadian Jay.

### Mexican and Mexico

Canada is not the only one short-changed in the common names of birds; so is Mexico. The 7th edition of the AOU Check-list of North American Birds includes seven species of birds with "Mexican" in the common name: Mexican Jay, Mexican Chickadee, Mexican Parrotlet, Mexican Sheartail, Mexican Woodnymph, Mexican Whip-poor-will, and West Mexican Chachalaca. If we consider Clements' *Birds of the World* and the *Handbook of the Birds of the World* (del Hoyo et al. 1992), sources that have worldwide recognition, there is an eighth species, the Mexican Anthrush (*Formicarius moniliger*). All of these species' names make sense because the entire breeding range or majority of the species' breeding range is in Mexico.

However, when looking at both the North American and South American lists, there are 16 species of birds with *mexicanus*, *mexicana*, or *mexicanum* in the scientific name, with 14 in the North American list and 2 on the South American list. None of these species has "Mexican" in the common name. As a curiosity, 3 of these 16 species are actually misnomers (erroneous toponyms): *Todus mexicanus* (Puerto Rican Tody), *Tangara mexicana* (Turquoise Tanager), and *Gymnomystax mexicanus* (Oriole Blackbird), which have never occurred in Mexico. The latter two species are found only on the South American list. Since the sci-

entific names are assigned by priority, no changes are suggested. However, if the geographical area of bird distribution is important in naming, many more species should be considered to be Mexican in the English common name.

## Summary

The important point of this discussion is that the use of the word "American" by the AOU North American Classification Committee as a synonym for North American is often inappropriate geographically and politically. It might be useful to suggest name changes that are more accurate. For example, the American Robin would be more properly called the North American Robin to better represent its range. (As an aside, this robin is not a robin but a thrush, so it might be better named the North American Robin Thrush.)

There are several possible routes to resolve this naming issue. The first approach could be cooperation, with Canada, Mexico, the Caribbean islands, the Central American countries, and the US all working together to remove the American bias in bird names. The AOU North American Classification Committee, at least insofar as common names are concerned, could be reformed to ensure that there is more equal membership from Mexico, the USA, and Canada, with some membership from the island areas. Most or all the birds that contain "American" could be renamed "North American", to more properly describe their range and to avoid the unfortunate nationalistic overtones. Another route could be the removal of the word "American" altogether. The AOU NACC has accepted the word "Eurasian", a hybrid of European and Asian, for those species that range over much of Europe and Asia. A new word could be developed to replace "American". Could this be Noramerican?

Another less cooperative approach might be for Canada and Mexico to go it alone—to establish their own nomenclature committees and then to work to ensure that such names are used in all publications and reports produced and sold in their countries. This would be similar to the Australian approach. However, we would recommend such an action only if the other solutions recommended in this paper are not adopted.

Probably the most appropriate approach is for the Committee on Classification and Nomenclature of North and Middle American Birds of the American Ornithologists' Union to be restructured along more representative lines and for this restructured commit-

tee to be more sensitive to geographical nomenclature and nationalist concerns in devising English common names. Similar logic should also be used for the French and the Spanish common names.

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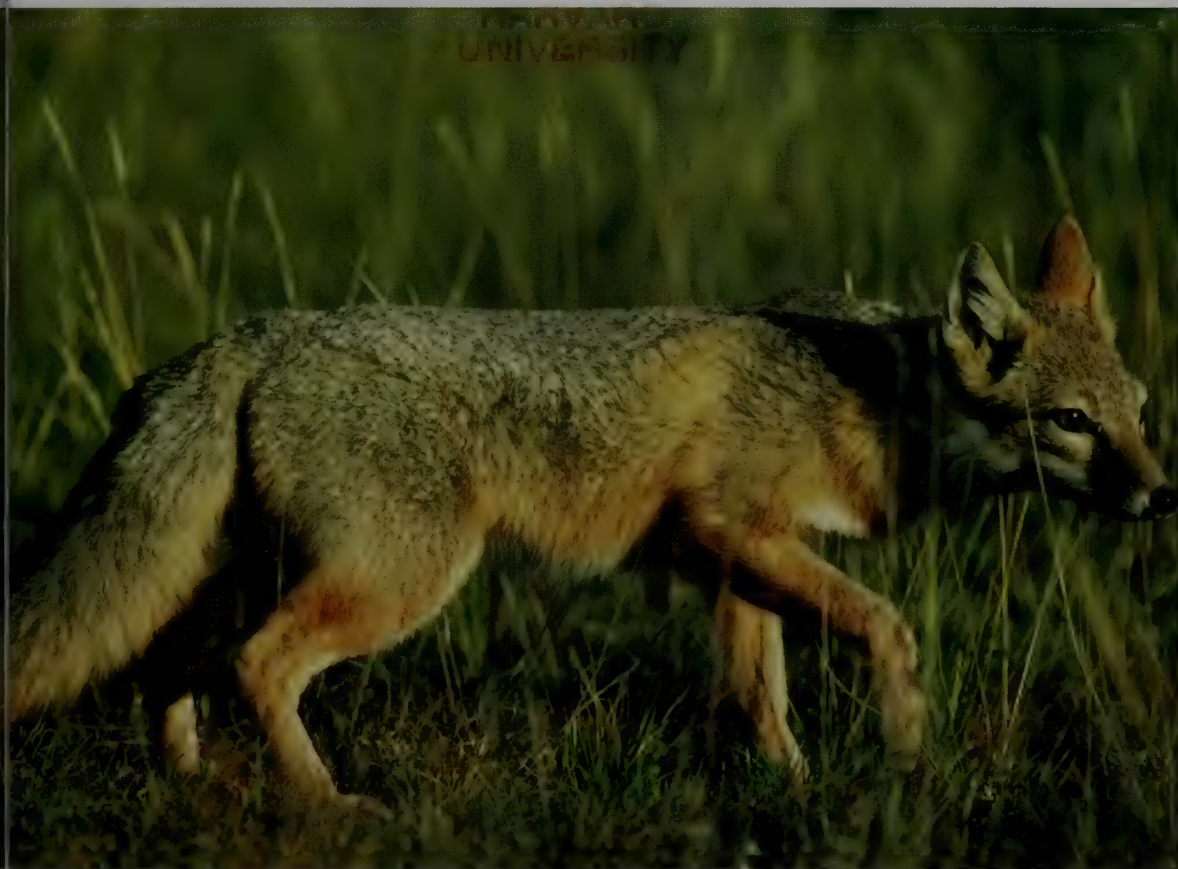
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COVER: A Swift Fox, *Velox velox*, Govenlock Community Pasture, Southern Saskatchewan, Fall, 1995. Photograph courtesy of Lu Carbyn (Canadian Wildlife Service and University of Alberta, Edmonton, Alberta). See paper by Marsha A. Sovada, Robert O. Woodward, and Lawrence D. Igl, pages 346–367.



# The Canadian Field-Naturalist

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## Wolf, *Canis lupus*, Visits to White-tailed Deer, *Odocoileus virginianus*, Summer Ranges: Optimal Foraging?

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Demma, Dominic J., and L. David Mech. 2009. Wolf, *Canis lupus*, visits to White-tailed Deer, *Odocoileus virginianus*, summer ranges: optimal foraging? Canadian Field-Naturalist 123(4): 299–303.

We tested whether Wolf (*Canis lupus*) visits to individual female White-tailed Deer (*Odocoileus virginianus*) summer ranges during 2003 and 2004 in northeastern Minnesota were in accord with optimal-foraging theory. Using GPS collars with 10- to 30-minute location attempts on four Wolves and five female deer, plus eleven VHF-collared female deer in the Wolves' territory, provided new insights into the frequency of Wolf visits to summer ranges of female deer. Wolves made a mean 0.055 visits/day to summer ranges of deer three years and older, significantly more than their 0.032 mean visits/day to ranges of two-year-old deer, which generally produce fewer fawns, and most Wolf visits to ranges of older deer were much longer than those to ranges of younger deer. Because fawns comprise the major part of the Wolf's summer diet, this Wolf behavior accords with optimal-foraging theory.

**Key Words:** Wolf, *Canis lupus*, White-tailed Deer, *Odocoileus virginianus*, predation, optimal foraging, Minnesota.

Two aspects of optimal-foraging theory involve optimal choice of food patches and optimal allocation of time to food patches of different value (Pyke et al. 1977). Wolves (*Canis lupus*) feeding on deer fawns (*Odocoileus* spp.) during summer are faced with such optimal foraging decisions, but heretofore it has been impossible to study this problem. Now new technology has made it possible, and we report a preliminary study as an example of what can now be accomplished.

Northern White-tailed Deer (*Odocoileus virginianus*) migrate to individual traditional summer ranges during spring (Ozoga et al. 1982; Nelson and Mech 1984; Nelson et al. 2004), and fawns are born there during an annual birth pulse that peaks in early June (Kunkel and Mech 1994). Parturient does space out from conspecifics and greatly restrict their movements as fawning approaches, and they continue to maintain exclusive sites during fawn-rearing (Nelson and Mech 1981). This behavior facilitates bonding between the mother and fawn(s), but also constitutes an optimum defense strategy against predators while young fawns are particularly vulnerable (Nelson and Mech 1981; Mech 1984; Kunkel and Mech 1994).

Reproductive performance in White-tailed does differs between young and older age classes. Because of

lower pregnancy and fecundity rates, two-year-olds produce fewer fawns per doe than older (three years and older) deer (Ozoga et al. 1982; Ozoga and Verme 1986; DelGuidice et al. 2007). Fawns are the primary prey of Wolves in White-tailed Deer range during summer (Frenzel 1974; Van Ballenberghe et al. 1975; Nelson and Mech 1986; Kunkel and Mech 1994).

Demma et al. (2007) characterized movements of five GPS-collared members of a Wolf pack in relation to summer ranges of GPS-collared female deer. All summer ranges of GPS-collared deer within the Wolf pack territory were visited by at least one GPS-collared pack member. Wolves visited the summer ranges of GPS-collared deer frequently (one Wolf visit per 3–5 days on average), and the amount of time GPS-collared Wolves spent in the summer ranges of GPS-collared deer varied from 1 to 22 hours.

Almost nothing else is known about summer Wolf interactions with deer because of the difficulty of studying this subject, but GPS collars afford a new opportunity to address the issue. Any piece of added information will begin to better elucidate the subject. Thus we present new information about the rate of visits by Wolves to the ranges of female deer of different ages. Because two-year-old female deer would generally

be accompanied by fewer fawns than older deer, optimal foraging theory predicts that Wolves would visit the ranges of the younger deer less often, other factors being equal. Thus we used GPS collars on Wolves and GPS and VHF collars on deer during the Demma et al. (2007) study to compare frequency of Wolf visits to the summer ranges of deer of both ages.

### Study Area

We conducted this study during the summers of 2003 and 2004 in the 240-km<sup>2</sup> territory of the Pike Lake Wolf pack in the Superior National Forest of northeastern Minnesota (48°N, 92°W) (Figure 1). Nelson and Mech (1981) provided a detailed description of the study area. Wolves occurred throughout the study area at densities of 28–36/1000 km<sup>2</sup> (L. D. Mech, unpublished data). The area is near the northern limit of deer range, and density was an estimated 12–15 deer/10 km<sup>2</sup> (M. H. Dexter, Minnesota Department of Natural Resources, unpublished report).

### Methods

During May–July 2003 and 2004, we live-trapped and anesthetized Wolves using standard techniques (Mech 1974; Demma et al. 2007). Wolves were examined for general condition, sexed, weighed, ear-tagged, and aged by tooth wear (Gipson et al. 2000). We took measurements of testes and teats to assess reproductive status (Mech 2006), and administered antibiotics.

We fitted the Wolves with GPS radio-collars that we programmed to obtain locations at either 10-min or 15-min intervals, 24 hours per day (Televilt, Lindesberg, Sweden, and Advanced Telemetry Systems, Inc. [ATS], Isanti, Minnesota, USA). The GPS collars contained either drop-off mechanisms that we programmed to release after 110 or 130 days post start-up (Televilt) or that we could release at will (ATS) by a remotely operated transceiver (Mech and Gese 1992).

We captured adult female deer during March 2003 and 2004 in collapsible Clover traps (McCullough 1975). The captured deer were anesthetized, examined, and sampled using standard techniques (Mech et al. 1985; Kreeger 1996; Nelson 2001). We attached a VHF radio-collar or releasable ATS GPS collar (Merrill et al. 1998). We programmed the deer GPS collars to obtain one location per week until 15 May and one location per 30 min thereafter. We remotely released the collars from the deer after the GPS battery level dropped below the threshold required to obtain fixes.

To minimize any potential movement bias resulting from capture and immobilization, we arbitrarily excluded Wolf GPS locations collected during the first five days post capture. We plotted all GPS data in ArcMap (ESRI, Inc., Redlands, California) and used Hawth's Analysis Tools ([www.spatialecology.com](http://www.spatialecology.com)) to calculate minimum convex polygons for deer (MCPs; Mohr 1947). We used this common method because

TABLE 1. Background data on VHF- and GPS-collared deer with home ranges that overlapped with GPS-collared Wolves during summer 2003 and 2004 in the Superior National Forest of northeastern Minnesota.

Year	Deer No.	Age	Number of locations	Collar type
2003	8066	3	9	VHF
2003	8070	7	11	VHF
2003	8076	2	9	VHF
2003	8080	2	7	VHF
2003	8082	5	11	VHF
2003	8084	2	803	GPS
2003	8094	3	2808	GPS
2003	8104	3	1359	GPS
2003	8110	2	739	GPS
2004	8066	4	9	VHF
2004	8070	8	11	VHF
2004	8076	3	9	VHF
2004	8080	3	7	VHF
2004	8082	6	11	VHF
2004	8110	3	7	VHF
2004	8114	3	7	VHF
2004	8118	7	12	VHF
2004	8126	7	11	VHF
2004	8142	3	10	VHF
2004	8144	2	9	VHF
2004	8158	8	1403	GPS

the MCPs of our GPS-collared deer included 739–2808 locations (Table 1) without large voids, thus minimizing two of the main MCP biases (White and Garrott 1990). We defined summer ranges of GPS-collared deer as MCPs comprising all locations from 15 May to 15 August. The MCPs generally contained dense point clusters with a few outliers that we arbitrarily excluded if they were >200 m away. The mean proportion of GPS locations excluded was 1%. Because many fewer locations were available for VHF-collared deer, we did not exclude outliers for MCP calculations. We combined 2003 and 2004 summer VHF locations for deer studied during both summers because female deer in this area use the same ranges each summer (Nelson 1979; Nelson and Mech 1984). We used a two-sample *t* test to compare mean MCP area calculated using GPS and VHF locations.

We calculated the frequency of Wolf visits to the summer range of each radio-collared deer by dividing the number of GPS Wolf visits by the number of GPS Wolf days. We calculated GPS Wolf days for each deer summer range by summing the study tenures of all GPS Wolves whose summer territories overlapped the deer ranges. We considered Wolf locations to be within deer MCP boundaries as visits, and we counted each visit as separate if Wolf locations and approximated travel paths (lines connecting successive locations) indicated that the Wolf left the deer summer range and had traveled >500 m away before revisiting or if it



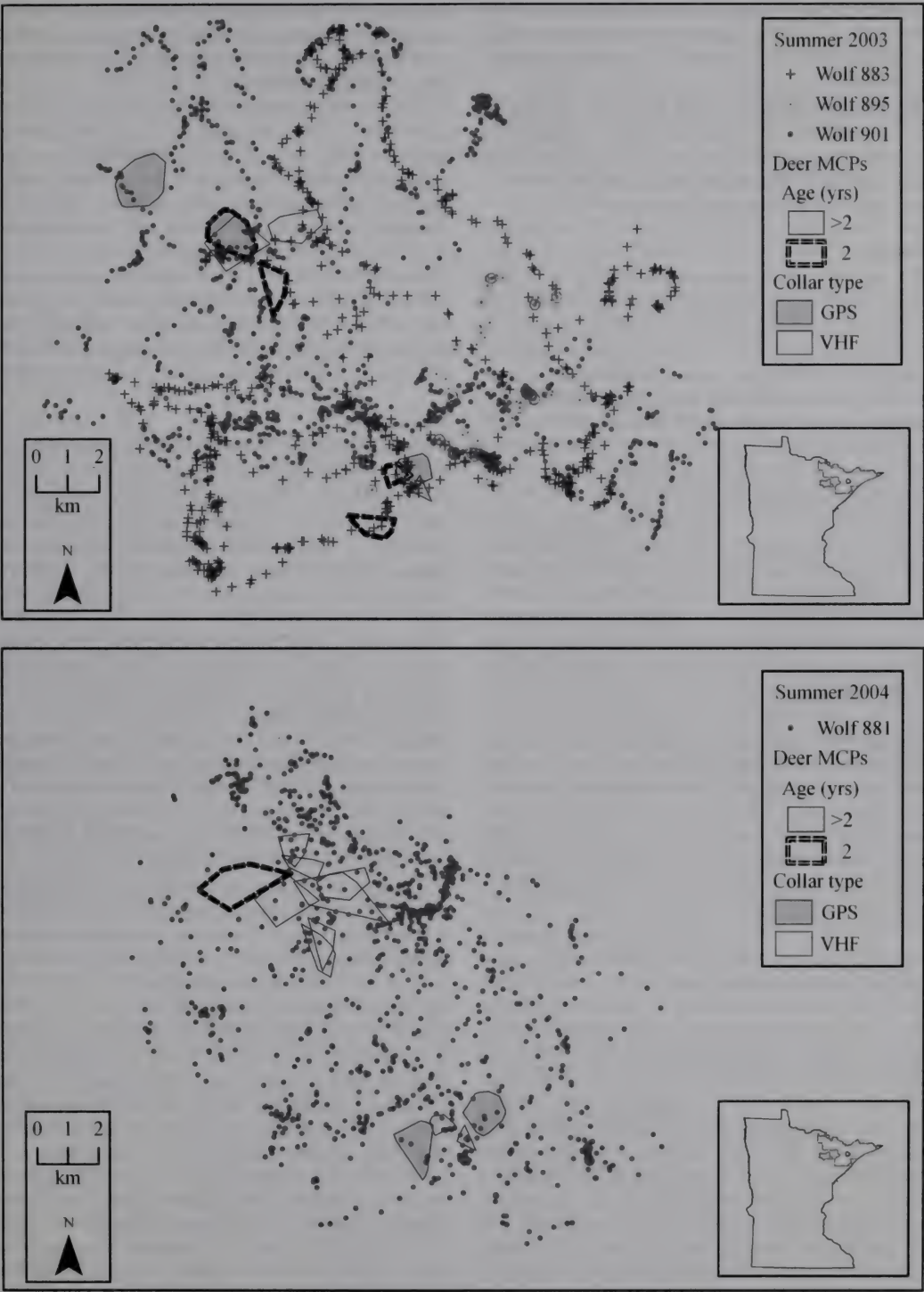


FIGURE 1. Locations of GPS-collared Wolves and locations of minimum convex polygons (MCPs) of VHF- and GPS-collared deer within Wolf pack territory during summers 2003 and 2004 in the Superior National Forest of north-eastern Minnesota.

returned  $\geq 12$  hours later. We also calculated Wolf visits to within 200 m of the boundaries of a deer MCP in case our deer MCPs were incompletely described (White and Garrott 1990).

We used a two-sample  $t$  test to test for differences in the mean frequencies of Wolf visits to young (two-year-old) versus older (three years old and older) deer and to test for differences in the mean time spent visiting each. We defined significance as  $P < 0.05$ .

## Results

We captured and instrumented three Wolves in 2003 and one Wolf in 2004 to study Wolf visits to deer summer ranges (Demma et al. 2007; Table 1). The study Wolves consisted of two females and two males, 1 to 8 years old. All Wolves were determined to be non-breeders (Mech 2006), with the exception of Wolf 881, an eight-year-old breeding male. Mean GPS study period per Wolf was 34 days ( $SD = 10$ ,  $n = 4$ ) and number of locations per Wolf averaged 1960 ( $SD = 804$ ,  $n = 4$ ).

We captured and instrumented with ATS GPS collars four deer in March 2003 and one deer in March 2004. Each deer migrated to summer ranges that overlapped spatially and temporally with GPS Wolf territories (Table 1). The GPS tenure of deer averaged 91 days ( $SD = 4$ ), and the mean number of GPS locations per deer was 1422 ( $SD = 833$ ). Mean area of summer MCPs, which included a nearby GPS-collared deer that did not overlap with any GPS-collared Wolves, averaged 137 ha ( $SD = 37$ ).

We captured, aged, and instrumented with VHF collars five deer in winter 2003 and six deer in winter 2004. Each deer migrated to summer home ranges that overlapped with GPS Wolf territories (Table 1). All five of the VHF-collared deer studied during 2003 returned to those summer ranges in 2004. The mean VHF MCP area (109 ha,  $SD = 78$ ) was less than, but not significantly different from ( $t_{15} = 0.81$ ;  $P = 0.43$ ), the mean GPS MCP area (137 ha,  $SD = 15$ ). The combination of the GPS and VHF radio-collared deer yielded a sample of five deer summers of data for two-year-old deer and 16 deer summers for deer three years old and older.

Our GPS-collared Wolf pack members visited the summer ranges of all radio-collared deer within the territory (Figure 1). Wolves made a total of 50 visits to summer ranges of GPS-collared and VHF-collared deer, with a mean of two ( $SE = 0.2$ ) GPS-collared Wolf visits per deer. Wolf 883 visited 9 of 9 deer summer ranges during a 33-day period, and Wolf 901 visited six of six deer summer ranges during a 32-day period, both in 2003. Wolf 895 had a study period of only five days and visited summer ranges of two of four radio-collared deer before dispersing from the territory in late June 2003 (Figure 1). Wolf 881 visited 12 of 12 known deer summer ranges in the territory during a 48-day study period in 2004. Although multiple Wolf pack members were radio-collared during 2003, the number of summer ranges of radio-collared deer over-

lapping each Wolf's range was different. This was due in part to temporal differences in Wolf study periods as well as to individual Wolf summer movement patterns within the territory.

Wolves visited summer ranges of two-year-old deer an average of 0.032 times/day and visited the summer ranges of older deer an average of 0.055 times/day ( $t_{19} = 2.1$ ;  $P = 0.05$ ). Wolves also spent much less average time visiting younger deer ranges (1.8 vs. 10.1 hours), although that difference was not significant ( $t_{3,3} = 1.5$ ;  $P = 0.22$ ). We also compared daily visits of Wolves to within 200 m of deer summer ranges in case our deer MCPs were incompletely described (White and Garrott 1990). Wolves made 0.044 visits/day to the 200 m-buffered MCPs of two-year-old deer and 0.075 visits/day to those of older deer ( $t_{19} = 2.0$ ;  $P = 0.06$ ).

## Discussion

Our GPS-collared Wolves visited the summer ranges of all radio-collared deer within their territory (Demma et al. 2007). They visited the summer ranges of deer three years old and older more frequently than those of two-year-old deer and most spent more time there, although average difference in time spent was not significant. Because deer three years old and older tend to produce more fawns than two-year-olds do (Ozoga et al. 1982; Verme and Ullrey 1984; Ozoga and Verme 1986; DelGuidice et al. 2007), the greater number of Wolf visits we observed to ranges of older deer is consistent with the assumed food value of those ranges. Older deer can produce one to three fawns per year, so multiple Wolf visits to summer ranges of older deer, even after a Wolf kills a fawn there, could lead to another kill. Thus return trips of Wolves to deer home ranges where fawns had already been killed would not necessarily result in reduced hunting success.

The amount of overlap among our deer summer ranges varied, and because not every deer in the Wolf territory was collared, we could not determine actual densities of prey patches in each deer MCP. The ranges of three of the five two-year-old deer did not overlap with any older radio-collared deer, but one other overlapped 38% with the range of an older deer and another overlapped 74% with the range of an older deer. Because such overlap could have confounded our analyses, we tested our results after eliminating those from the two younger deer that overlapped with the older ones, and the results were still significant.

Our estimated number of Wolf visits to deer home ranges increased with the addition of the 200-m buffer. However, most Wolf visits were within the core MCP boundaries of GPS- and VHF-collared deer, and comprised 71 and 73% of total visits, respectively. We feel that the addition of the 200-m buffers (and corresponding Wolf visits) to the deer home ranges, albeit somewhat arbitrary, is a reasonable method to estimate Wolf visits to deer home ranges that may be underestimated by location data.



With or without the buffer, the behavior of the Wolves we studied accords with optimal foraging theory (Pyke et al. 1977), and suggests that even Wolves facing their initial summer of hunting deer fawns soon learn which food patches to visit more frequently.

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# Suspected Long-Term Population Increases in Common Eiders, *Somateria mollissima*, on the Mid-Labrador Coast, 1980, 1994, and 2006

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Aerial surveys for adult male Common Eiders, *Somateria mollissima*, were flown on the Labrador coast during June 2006. This information was then compared with aerial counts of adult male Common Eiders collected in 1980 and 1994. For each survey year, data were grouped and paired by coastal block and were analyzed for population trends. Overall, the observed counts of adult male Common Eiders increased by 244% between 1980 and 2006. Much of this increase seemed to occur in the southern region of the study area.

**Key Words:** Common Eider, *Somateria mollissima*, aerial survey, population trends, Labrador.

In the last decade, declines in the populations of Common Eider (*Somateria mollissima*) have been documented in various regions of the north, such as Hudson Bay, the Beaufort Sea, and western Greenland (Robertson and Gilchrist 1998; Suydam et al. 2000; Merkel 2004). Factors identified as causing these declines include human disturbance, over-harvesting, and climatic events. However, not all Common Eider populations are decreasing. Christensen and Falk (2001) found evidence of population stability in north-west Greenland, and others have documented increases in Hudson Strait (Hipfner et al. 2002; Falardeau et al. 2003) and in the Gulf of St. Lawrence (Cotter and Rail 2007; Rail and Cotter 2007).

With respect to Labrador, from 1998 to 2003, Chaulk et al. (2005) documented average annual increases in Common Eider populations of 18% (range 13–22%). However, that study was limited in temporal and geographic scope, and thus the overall direction and extent of longer-term population trends for the region remained unclear. This study examines counts of adult male Common Eiders on the mid-Labrador coast over a 26-year period using data collected during three time periods, in 1980, 1994, and 2006.

## Study Area

The study area, located in the sub-Arctic on the mid-Labrador coast, is approximately 19 714 km<sup>2</sup> (Figure 1) and contains 5296 islands and islets ranging in size from 0.01 to 7205.77 ha, with an average island size of 22.90 ha (unpublished data). All islands share similar environmental characteristics, such as a northern maritime climate and vegetation composed primarily of moss, lichen, forb, grass, and sedge. The region is considered to have a low Arctic oceanographic regime (Nettleship and Evans 1985) and is classified as a coastal barrens (Lopoukhine et al. 1978). Two subspecies of Common Eider occur in the study area: *S.*

*borealis* occurs throughout, while the northern edge of the range of *S. m. dresseri* intersects the southern portion of the study area (Mendall 1980; Goudie et al. 2000; Chaulk et al. 2004). The line of demarcation between the two subspecies is not well established, and some have suggested that a hybridization zone occurs in the region of Groswater Bay (Mendall 1980), the center of which lies at about 54°20' north latitude and is adjacent to the community of Rigolet (Figure 1).

## Methods

From 6 to 24 June 2006, aerial surveys were flown on the mid-Labrador coast (Figure 1) using a twin engine Normandy Islander; flight altitudes ranged between 200 and 300 m Above Sea Level and air speeds ranged between 150 and 180 km/h; sea ice was absent from all survey areas. The 2006 surveys involved one observer/navigator, one rear observer, and one pilot. Data from 2006 were then compared to surveys conducted in 1980 and 1994. The 1980 surveys (18 June to 20 July) were flown with one observer/navigator and one pilot (Lock 1986). The 1994 surveys (17 June to 8 July) used one observer/navigator, two rear observers, and one pilot (S. Gilliland, unpublished). In all cases, the pilot assisted with observations.

All coastal shorelines (mainland and island) within the study area (Figure 1) were surveyed in 1980, 1994, and 2006. The 1980 and 1994 surveys covered the entire coastline of Labrador (Lock 1986; Gilliland, unpublished), while the 2006 survey was about one-third the coverage of the previous surveys (Figure 1). All surveys started in the south and moved northwards.

In this paper, only data from the section of coast surveyed in all three years and highlighted in Figure 1 are reported. In 1980 and 1994, count data were recorded on paper maps and later compiled by coastal block (see below). In 2006, the United States Fish and Wildlife GPS Voice Survey Recording program (v. 3.1) was



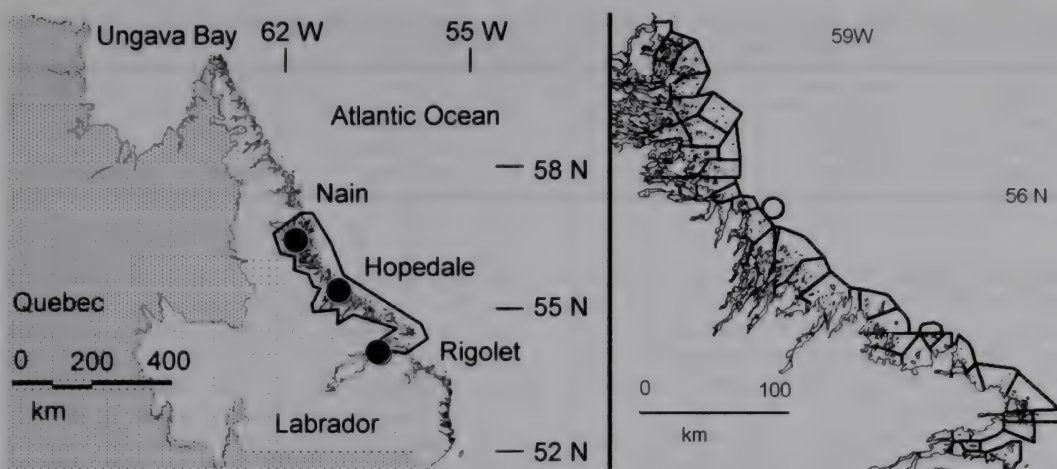


FIGURE 1. Location of the 2006 study area on the mid-Labrador coast. Left panel shows all of Labrador with the 2006 study area highlighted; right panel illustrates only the 2006 study area and the distribution of the 64 coastal blocks surveyed in all three years (1980, 1994, and 2006).

Note: the 1980 and 1994 surveys included areas north and south of the blocks illustrated; however, only data from the 64 coastal blocks (shown in right panel) (surveyed in 1980, 1994, and 2006) are presented and analyzed in this paper.

used to record all observations (Chaulk and Turner 2007), which were subsequently compiled by coastal block.

To allow the data sets across years to be summarized and compared across years, all count data were compiled by coastal block, a grid system developed by the Canadian Wildlife Service to partition the Labrador coast into discrete survey units based on prominent landscape features (Gilliland, unpublished). For purposes of statistical testing, the same 64 blocks surveyed in 1980, 1994, and 2006 were “paired” and analyzed for trends (Figure 1). The average size of these 64 coastal blocks was 308 km<sup>2</sup> (SD = 185.3).

Coastal blocks were then sorted from south to north by the geographic center, and adjacent coastal blocks were grouped into aggregate blocks. Each of the four resulting aggregate blocks was composed of 16 coastal blocks (4 × 16 = 64). The aggregate blocks were consecutively labelled 1, 2, 3, 4, with 1 being the most southerly and 4 the most northerly. The 95% confidence interval for the mean was calculated for each aggregate block and plotted by survey year. This exercise was performed to illustrate regional and annual variations within the overall data set.

As the study team progressed northwards along the coast in 2006, approximately 20–30 nests were candled (Weller 1956) in each of the archipelagos of Rigolet, Hopedale and Nain to assess stage of incubation (Figure 1).

Throughout the paper, all reported ± values are 1 SE (except where noted). No data transformations were used, and non-parametric Friedman’s test (predictors:

Year and Block ID) and pair-wise *t*-tests of the count data were conducted using Minitab version 14.1.

## Results

Candling revealed that the 2006 survey occurred between the first and second week of nest initiation. In 2006, total adult male Common Eider counts were 17 374 (number of flocks = 1733, mean flock size = 10.03 ± 0.63). Of these, 13 014 (i.e., 74.9%) adult male Common Eiders were associated with islands (number of flocks = 1332, mean flock size = 9.77 ± 0.69), and approximately 80% of these were associated with islands smaller than 30 ha. The average number of adult males/island was 15.6 ± 1.2 (number of colonies = 834).

The mean number of male Common Eiders per coastal block increased from a low of 111.3 ± 17.2 in 1980 to 271 ± 41.3 in 2006 (Table 1), a population increase of 244%. Using a Friedman’s test, counts were found to differ significantly by year (*P* < 0.001); pair-wise *t*-tests indicated that 2006 counts were significantly higher than 1980 (*P* < 0.001). Interval plots revealed little change in counts across years in northern sections of the study area; these plots showed that most of the increases occurred in the southern portion of the study area (Figure 2).

## Discussion

Based on informal interviews at the start of surveys, many local residents of Labrador stated that 2006 was an early spring, perhaps four weeks earlier than historical norms. Visual analyses of ice charts for the

TABLE 1. Left panel summarizes observations of adult male Common Eiders on the mid-Labrador coast by survey year ( $n = 3$ ) and aggregate block ( $n = 4$ ). Right panel summarizes pair-wise  $t$ -tests by year.

Year	Total Count	Average Count (SE)	Years	$P$	$t$ -value
1980	7 120	111.3 (17.2)	1980, 1994	0.001	-3.59
1994	13 994	218.7 (39.5)	1994, 2006	0.109	-1.62
2006	17 374	271.5 (41.3)	1980, 2006	0.000	-4.60

study area support this assessment and also suggest that 1980 and 1994 were similar with respect to the timing of spring ice break-up. First indications of major open water can be found on the ice charts of 22 June 1980, 19 June 1994, and 15 May 2006 (Canadian Ice Service Online Data 2010\*).

Although the 1980 surveys did not report stage of incubation, the author indicates that the surveys commenced approximately 10–12 days after the start of laying (Lock 1986). Unfortunately, the 1994 surveys did not provide any information on the timing of nesting (Gilliland, unpublished). Based on estimated nest ages (eggs in 2006 were 7 to 14 days old), the timing of the 2006 surveys was similar to the 1980 surveys. It should be noted that both Lock and Gilliland initiated their surveys several hundred kilometres to the south and took up to one week to reach the point at which the 2006 surveys started. Adjusting for the overlapping study area (Figure 1), the 2006 surveys started approximately three calendar weeks earlier than surveys in 1980 and 1994.

However, even with the earlier survey start date and earlier spring conditions in 2006, I feel that, relative to breeding, the 2006 surveys were comparable to the 1980 surveys (i.e., within 10 days) (see discussion above of ice conditions and nest ages of all three surveys). However, owing to the absence of information on nest ages at the time of the 1994 surveys, it is not possible to state with rigor how all survey years compared with respect to the nesting period.

It is very likely that across-year environmental differences influenced the start of breeding in each of the survey years and that this would consequently affect observed counts, although the direction (resulting in higher or lower counts) of these effects, relative to survey year, remains unknown. If Common Eiders nested early in 2006 due to lack of ice, adult males may have started to disperse by the time of the survey, reducing the overall count. For example, it has previously been suggested that ice influences the nesting behaviour of eiders (Lack 1933; Ahlen and Andersson 1970; Quinlan and Lehnhausen 1982; Parker and Mehlum 1991; Chaulk et al. 2007), and male Common Eiders are known to disperse from breeding islands shortly after females begin nesting (Goudie et al. 2000).

Uneven observer effort is another factor that could have influenced comparison of count data across years (Caughley 1974). Laursen et al. (2008) found that detection rates were approximately 80% for species

with densities of more than 10 individuals/km<sup>2</sup> and that observer effects are less pronounced in species that form large flocks. It should be noted that in 2006 the average was approximately 10 Common Eiders/flock. Estimates of average flock size from other survey years were not reported, so at present this information is limited as an indicator of across-year detection rate(s). However, the 2006 flock size data could be useful comparison information in the event of future surveys. With this said, it is not clear how average flock size changes with population fluctuation. One might assume that flocks become larger as the population increases, but behavioural processes and availability of forage likely play a role in shaping the relationships between flock size and overall abundance.

As indicated in the methods, each survey year involved a different number of observers, with 1980 having the least (two), 2006 surveys having an intermediate number (three), and 1994 having the most (four). The effects that observer effort had on counts are unknown, but likely contributed to across-year differences. However, the direction (resulting in higher or lower counts) of these effects relative to each survey year also remains unknown.

Figure 2 depicts regional differences within the study area with respect to long-term population trends. Mean counts were relatively constant across years in the north, while southern sections showed larger across-year differences. Thus many of the suspected long-term increases seem to be driven by population processes in the southern portion of the study area. Within the study area, the southern section is thought to be a region of overlap and hybridization between the northern and southern subspecies of the Common Eider (Mendall 1980; Chaulk et al. 2004). It is possible that interactions between these two subspecies are influencing the overall apparent population growth.

It is true that this study suffers from several limitations with respect to the comparability of the data across years (observer effort, survey timing); however, in combination with findings presented by Chaulk et al. (2005) as well as anecdotal reports by local hunters, it seems to provide growing evidence that suggests that Common Eider populations on the mid-Labrador coast have grown since the early 1980s. The cause(s) of these apparent increases are unknown.

One explanation relates to changes in human land use during the breeding period as a result of the closure of coastal in-shore fisheries in the early 1990s.



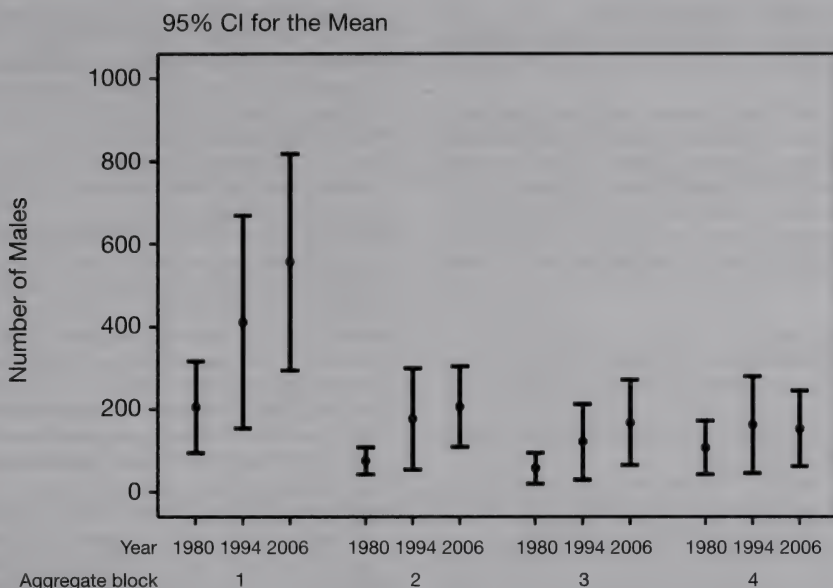


FIGURE 2. Interval plots of adult male Common Eider counts by aggregate block and year. Data means and 95% confidence intervals are based on surveys conducted on the mid-Labrador coast in 1980, 1994, and 2006. Each aggregate block ( $n = 4$ ) is composed of 16 adjacent coastal blocks. Aggregate blocks are labelled 1 to 4 and are ordered from south to north, where aggregate block 1 is the most southerly and 4 the most northerly.

Note: For purposes of graphing, aggregate blocks ( $n = 4$ ; by 3 years) were used instead of coastal blocks ( $n = 64$ ; by 3 years) in order to reduce data clutter.

For example, a reduction in fish offal may have had an impact on local gull populations, thereby decreasing gull predation on Common Eider nests (Gotmark 1989; Mawhinney et al. 1999). In addition, the closure of the in-shore fishery likely resulted in less disturbance of breeding colonies (Gotmark and Ahlund 1984; Laursen and Frikke 2008) by fishing boats, as well as possible reductions in eggging and the harvest of adult birds.

Northland Associates (1986\*) report that the mean household harvest of Common Eiders in 1980 by the Inuit communities of Hopedale was 52.9 ( $n = 21$  households) and Postville was 29.1 ( $n = 21$  households). Felt and Natcher (*in press*) report that the mean household harvest of Common Eiders in the same communities in 2007 was 19.0 in Hopedale ( $n = 41$  households) and 9.0 in Postville ( $n = 26$  households). Thus harvest levels in 2007 were lower than in 1980; it is unknown whether other communities in the study area reduced their harvest of Common Eiders over this period.

Other possible, albeit undocumented, explanations for apparent increases in counts of Common Eiders include hunter education and conservation awareness

programs, habitat enhancement programs (i.e., nest shelter), and/or an amelioration of environmental conditions resulting from climate change. Education and nest shelter programs were initiated in Labrador in the mid-1990s, but assessments of their effect on populations of Common Eiders have not been widely reported. With respect to the regulation of migratory bird harvest, this region of Labrador continues to have a limited enforcement presence.

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# Apparent Continuing Expansion in the Range of the Gray Treefrog, *Hyla versicolor*, in New Brunswick

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Recent observations of the Gray Treefrog, *Hyla versicolor*, in the Maritimes suggest that this species may be expanding its range and abundance, perhaps partly in response to human activities. However, during the breeding season the species characteristically calls in very small choruses in the region and may be present but not call, or call for very short periods. This has made it difficult to determine distribution and to make an assessment of unconfirmed historic records that suggest presence beyond the current range more than 50 years ago. The inadvertent introduction of frogs may also be playing a role in the apparent recent range expansion of this species.

**Key Words:** Gray Treefrog, *Hyla versicolor*, distribution, New Brunswick, Nova Scotia.

The Gray Treefrog (*Hyla versicolor*) reaches its northeastern range limit in New Brunswick (Logier 1952, without citing a specific locality) although it is common elsewhere in Canada from southern Manitoba to southwestern Quebec (Cook 1984; Desroches and Rodrigue 2004). As recently as 1980 the species was known in the Maritimes only from Barker's Point, New Brunswick, a marsh about 120 km northeast of the nearest Maine population (Bleakney 1954; 1958; McAlpine et al. 1980). At that time concern for the survival of the Gray Treefrog in New Brunswick was such that it was proposed as a candidate for endangered species status in the province (Stewart 1974; Majka 1981). Canada's first protected site for an amphibian was established in New Brunswick on behalf of this species (McAlpine and Vail 2005). However, investigations in 1980–1990 in southwestern New Brunswick showed *H. versicolor* to be neither rare nor endangered in the province (McAlpine et al. 1991) and the species is now considered secure (CESCC 2006). McAlpine (1997) suggested that the species range in New Brunswick was expanding, perhaps partly in response to access to suitable breeding habitat created through human activities. Here we document what appears to be continuing expansion in the range of this species in the Maritimes.

Information on calling Gray Treefrogs was collected opportunistically following reports of calling and through field investigation in suitable habitat during the known calling period for the region. Calls were recorded on several occasions using hand-held cassette recorders and the pulse repetition rates were measured from sound spectrograms (Spectrogram v 15.0, Visulizing Software LLC). Where possible voucher specimens were also collected and have been deposited

in the collections of the New Brunswick Museum (NBM).

McAlpine et al. (1991) documented new locations for the Gray Treefrog in western New Brunswick, mostly along the Maine-New Brunswick border, which closed the distributional gap between Barker's Point and Maine populations to about 68 km. The Gray Treefrog has been known to be resident at Barker's Point since about 1935 and in the general area since about 1899 (McAlpine et al. 1980). In 2002 a single *H. versicolor* was reported to call for about 15 minutes on 22 July at English Settlement (46.261°N 66.730°W), York County, about 30 km north of Barker's Point, by long-time residents and local naturalists Robert Whitney and Julie Singleton. No other calling was noted in that year. At least three frogs were heard calling at English Settlement on 17 June 2003. Calling has been noted from Magaguadavic (45.766°N 67.164°W) west to McAdam (45.594°N 67.164°W), York County and north to North Lake, Canelton County (45.820°N 67.721°W) on the Maine-New Brunswick border (D. L. Sabine, A. W. Thomas, personal communication to DFM).

On 1–2 July 2004 a single Gray Treefrog was photographed and the call recorded at a pond close to a large roadside farm market near Wolfville, Kings County, Nova Scotia (45.085°N 64.387°W). The frog called for several weeks at the site but no Gray Treefrogs have been heard calling at the pond in subsequent years. Analysis of the call, which presents a pulse rate of 20.8/sec, confirms that the frog is *H. versicolor* (Figure 1), which has a significantly slower pulse repetition rate at a given air temperature than its sibling species, *H. chrysoscelis* (Cope's Gray Treefrog) (Bogart and Jaslow 1979). Air temperature data from

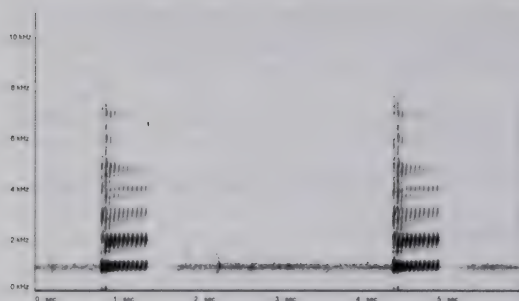


FIGURE 1. Sound spectrogram showing two trills of *Hyla versicolor* (analyzing bandwidth of 86.1 Hz). Recording was made 2 July 2004 at Wolfville, Nova Scotia.

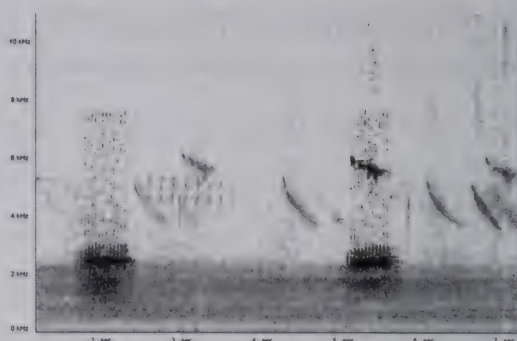


FIGURE 2. Sound spectrogram showing two trills of a *Hyla versicolor* (analyzing bandwidth of 21.5 Hz). Recording was made 26 June 2005 at St. Jacques, New Brunswick. Accompanying down-sweeps are Red-winged Blackbird calls (*Agelaius phoeniceus*); traffic noise occupies the 0-2 kHz range.

the Environment Canada Hourly Data Report ([www.climate.weatheroffice.ec.gc.ca](http://www.climate.weatheroffice.ec.gc.ca)) recorded at the nearby Kentville weather station suggests air temperature at the calling site was in the low 20s°C the night the recording was made.

On 25-26 June 2005 Roy LaPointe recorded a single Gray Treefrog calling at about 2130 hrs at a recorded air temperature of 23°C at St. Jacques (47.416°N 68.383°W.), a community near Edmundston, Madawaska County, New Brunswick. Analysis of the call, showing a pulse rate of 25.0/sec (Figure 2), demonstrates that the species is also *H. versicolor*. The frog was calling from hardwood trees surrounding a wetland area created in waste land adjacent to the Trans-Canada Highway. DFM and others visited the site on 26 June 2008. Weather data suggests that air temperature was several degrees warmer than in 2005 but no Gray Treefrogs were calling. Other apparently suitable wetlands in the area were also visited that night without success.

On 2 July 2008 DFM and JDHP visited Minto, Queens County, New Brunswick following reports of calls believed to be those of *H. versicolor* heard between 7 June and 1 July 2008. Small choruses were confirmed at two sites and voucher specimens collected (NBM 8852, 8853). Sites were typical wetlands for the species in the province. Fewer than 10 frogs were calling from a Beaver pond off a meander in Newcastle Stream (46.074°N 66.067°W) and two frogs were calling from a small roadside pond (46.084°N 66.029°W) created through excavation about 3 km northeast of the Beaver pond. No Gray Treefrogs were heard calling on previous trips to these sites by DFM on 9 and 14 June 2008, although a strong chorus was calling in light rain on the first evening at the long-known Barker's Point site, about 50 km southwest. Figure 3A plots the distribution of historic and new Gray Treefrog records reported and discussed here.

The observations above support earlier suggestions that the distribution and abundance of this species at

the margin of its northeastern range (see Figure 3B) may be enhanced by human activities. Calling sites typically occur where small-medium size wetlands have been created through road construction or the removal of the overburden. Association with Beaver ponds is also common. Documenting the species presence through calling has often been opportunistic as it has proven difficult to predict when or if small choruses will be calling during the breeding season. Ritke et al. (1992) found that climatic conditions alone are not responsible for initiating breeding activity in the closely related *H. chrysoscelis* but suggested that the presence of gravid females may be important. Although *H. versicolor* is cryptic, it is tempting to believe it is unlikely to have been overlooked previously over such a wide range in New Brunswick, especially given the frequency with which reports are now being received. Nonetheless, the recent "rediscovery" of *Pseudacris brimleyi* (Brimley's Chorus Frog) on the 80, 267 ha Savannah River Site, Georgia, after more than 50 years of relatively intense herpetological study (Luhning 2008), emphasizes how difficult it can be to detect the presence of some species and to pronounce on species presence, absence, or range expansion.

The St. Jacques record lends credence to unsupported 1947 and 1955 reports for three *H. versicolor* caught in insect light traps near Third Lake, Madawaska County, a site about 45 km north of the St. Jacques (see McAlpine et al. 1980, Figure 3A). St. Jacques falls within several narrow extensions of the federally established Saint John River Valley Ecoregion that follow river valleys in northern New Brunswick. Although Third Lake is in a different ecoregion (Northern New Brunswick Uplands), seasonal temperature and rainfall regimes for the two regions are very similar (Ecosystem Stratification Working Group 1995). The somewhat different provincial land classification system for





FIGURE 3(A). Historic and current reports of the Gray Treefrog in the Maritimes showing expanding understanding of range. Dots indicate confirmed occurrences; lines enclose estimated range. Approximate year at which presence was first demonstrated is also shown; (B). Inset, modified after Elliott et al. (2009) Shows North American range for the Gray Tree Frog with current distribution in the Maritimes incorporated. The isolated Nova Scotia report is not included.

New Brunswick reflects this in that both these sites are encompassed by Madawaska Ecodistrict 3-1 (Zelazny 2007). Given the sproadic nature of calling in this species at the northern edge of its range, it is worth noting that observers at Third Lake specifically noted that they had never heard the species calling in 1947 or 1955. However, past confusion with the abundant and widespread Spring Peeper (*Pseudacris crucifer*), make it difficult to assess the reliability of historic reports that are unsupported by specimens (Majka 1974).

It is likely that the Gray Treefrog recorded in Wolfville is an introduction, perhaps inadvertent. Although recorded for the province by Jones (1865) on the basis of a single second-hand report, and later by McKay (1896), the presence of this species in Nova Scotia has been discounted (Bleakney 1958; Gilhen 1984). The Wolfville site is along a secondary, but heavily travelled, highway and receives significant tourist traffic. The market farm where the frog was recorded is equipped with greenhouses that receive plant shipments from the eastern United States, a nature trail, and some exotic species are kept in a small petting zoo. Nonetheless, given the possible range expansion underway in adjacent New Brunswick, the often small choruses that characterize this species here, and that frogs may be present but may call infrequently, or perhaps not at all in some years, this occurrence in Nova Scotia is noteworthy. The inadvertent movement of *H. versicolor* on shipped plant material, logging trucks, and by other means should not be overlooked as a mechanism in what may be this species on-going dispersal in the region.

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# Effects of Stochastic Flood Disturbance on Adult Wood Turtles, *Glyptemys insculpta*, in Massachusetts

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The homing ability of non-marine turtles has been studied in a variety of taxa, and many species appear to be capable of short-range homing on the scale of several hundred meters or a few kilometers following experimental displacement. However, the behavioral response of turtles following a naturally caused displacement has seldom been reported. In this paper, we describe the effect of displacement ranging from 1.4 to 16.8 km (average = 4.8 km) by severe floods in a stream system in Massachusetts. We radio-tracked 38 adult Wood Turtles (*Glyptemys insculpta*) at five separate sites in Franklin County, Massachusetts, for periods ranging from one to four activity seasons and documented the displacement of a total of 12 Wood Turtles during seven floods between 2004 and 2008. Based on the average rate of displacement per flood and annual flood frequency, we estimate that, during our study, floods displaced over 40% of this Wood Turtle subpopulation annually. We present evidence that displacement results in elevated mortality rates and that displaced Wood Turtles mate and nest in the year following displacement at rates well below average; on a longer time scale, however, displacement by flooding may be an important mechanism of population connectivity in some areas. We also present evidence that most Wood Turtles avoid stream segments with stream gradient steeper than 1%; this may in part reflect an adaptation to avoid severe floods. Regional models and empirical data from stream gages suggest that flood intensity may currently be on an increasing trend. Conversion of upland from forest and fields to impervious surfaces and hardening of upstream riverbanks may have exacerbated recent flooding and decreased the resiliency of the riparian system to increased precipitation.

**Key Words:** Wood Turtle, *Glyptemys insculpta*, freshwater turtles, floods, rivers, disturbance, stream gradient, climate change, Massachusetts, New England.

Many species of non-marine turtle appear to be capable of “homing”, or navigating toward familiar territory, after experimental displacement on the scale of several hundred meters or several kilometers. For example, homing has been experimentally demonstrated in the emydid species *Clemmys guttata* (Ernst 1968), *Glyptemys insculpta* (Carroll and Ehrenfeld 1978; Barzilay 1980), and *Terrapene carolina* (Nichols 1939; Gould 1957; Mathis and Moore 1988). Relatively large movements have been documented in free-ranging turtles, for example, *Terrapene coahuila* (to 9.7 km; Howeth et al. 2008), *Glyptemys insculpta* (to 3.7 km; Walde et al. 2007) and *Gopherus agassizii* (to over 32 km; Schwalbe et al. 2002\*).

Although the homing phenomenon has been explored through experimental displacement for nearly a century, natural causes of displacement are rarely reported or discussed. The sensing abilities that allow turtles to head in a homeward direction following displacement probably also assist turtles in locating and navigating to important landscape features within their home range, but regular displacement in an ancestral aquatic environment could have contributed to the adaptation of homing abilities. In many stream systems, floods are the most likely source of long-distance, involun-

tary, non-lethal displacement of adult turtles, and these systems provide an opportunity to study both the effect of major stochastic flood disturbance on populations of stream-dwelling turtles and the behavioral response of individuals to displacement over multiple kilometers.

Flooding influences riparian ecosystems by altering channel geomorphology and floodplain vegetation, by connecting the primary stream corridor to isolated floodplain wetlands, by facilitating dispersal of organisms, and by drowning, injuring, or displacing individual animals (Goldthwait 1928; Collins et al. 1981; Hupp 1982; Jones 1996; Anderson et al. 2000). The size and frequency of floods are generally the products of complex interactions among land uses within a watershed, watershed area, tributary and main channel slope, valley shape, and precipitation frequency (Goldthwait 1928; Horton 1945; Wong 1963), although Wong (1963) demonstrated that mean annual floods in New England can be modeled using only stream length and average land slope, suggesting that large, high-gradient streams are prone to floods of the largest volume and power. Floods are also more pronounced in streams with constrained valley walls (Wong 1963). In northern and high-elevation regions, winter and spring floods are generally more severe than summer floods,

TABLE 1. Elevation, watershed area, and stream size at field sites in Franklin County, Massachusetts, USA. For definitions of forested vs. agri-forested landscapes, see Saumure et al. (2007).

Site	Elevation (m)	Watershed area (ha)	Average stream width (m)	Number of turtles with transmitters	Upland site characteristics
A	221–268	281	5.1	8	Forest
B	247–258	418	7.5	9	Agri-forest
C	145–203	1 770	12.7	9	Agri-forest
D	91–96	1 987	15.48	11	Forest
E	41–49	46 227	50.7	11	Agri-forest

because, in addition to the compounding factor of snowmelt, streamside snowpack increases the height of the stream bank and constrains elevated flows (Erman et al. 1988).

The effect of floods on aquatic vertebrates, primarily fish, has been documented in several systems (e.g., Elwood and Waters 1969; Collins et al. 1981; Erman et al. 1988; Jowett and Richardson 1989; Strange et al. 1992). Several studies have indicated that seasonal flooding influences the behavior of individual turtles, for example, Jones (1996) found that Yellow-blotched Map Turtles (*Graptemys flavimaculata*) alter their behavior seasonally to accommodate or exploit high-flow conditions. Selman and Qualls (2008) subsequently presented evidence that *Graptemys flavimaculata* may have been negatively affected by flooding associated with Hurricane Katrina in 2005. Pluto and Bellis (1988) observed that Common (Northern) Map Turtles (*Graptemys geographica*) in Pennsylvania selected deep, slow riverine environments in the fall and made large upstream movements during low-flow conditions. Similarly, Moll and Legler (1971) reported downstream movements of Common Sliders (*Trachemys scripta*) during high-flow events, and Ernst (1974) documented habitat shifts, decreased recruitment, and increased depredation of adult Eastern Painted Turtles (*Chrysemys picta*) following Hurricane Agnes in 1972. Floods may negatively affect, or displace, terrestrial turtles: Stickel (1948, 1978) reported that although severe floods in 1945 did not have a negative impact on a Maryland population of the terrestrial Eastern Box Turtle (*Terrapene carolina*), floods in 1972 may have contributed to a marked population decline.

Additional studies have presented evidence for morphological distinction between populations of freshwater turtles in lentic and lotic habitats, suggesting that some riverine species develop body dimensions that reduce drag (e.g., *Emys marmorata*, Lubcke and Wilson 2007; *Pseudemys concinna*, Rivera 2008).

These studies do not specifically address population- and individual-level effects of displacement by large floods. Direct evidence of displacement by flooding is rare and is mostly confined to stream-dwelling species, e.g., *Emys marmorata* (see Ashton et al. 1997\*; Rathbun et al. 2002; Alvarez 2005\*), *Glyptemys insculpta* (Barzilay 1980, Sweeten 2008), and *Kinosternon sonoriense* (see Collins et al. 1981; Stitt and Swan 2000\*).

Rathbun et al. (2002) suggest that winter flooding associated with the Mediterranean climate of California may have been partially responsible for terrestrial hibernation in some stream-dwelling populations of *E. marmorata*. These examples provide evidence of downstream displacement, but only Sweeten (2008) provides observations of extensive post-displacement behavior. Latham (1971) reported dead *Glyptemys insculpta* washed up in eastern Long Island after heavy rains in New England, providing anecdotal evidence that displacement caused by flooding may occasionally be extreme, and fatal.

Hypothetically, displacement by flooding, if not fatal, may significantly influence population dynamics. Displaced turtles may mate with downstream turtles, or they may lay eggs at the downstream location. If turtles move back to their original location, they may encounter habitats en route that are later incorporated into regular seasonal movements. Because some sites may be disproportionately affected by floods as a result of geomorphology, they may suffer a net loss of turtles over time if turtles do not successfully return. Overall, the direct effects of flooding on the behavior and survival of freshwater turtles have been largely neglected.

Wood Turtles are a good species in which to examine the effect of displacement by flooding on the behavior of individual turtles, as Wood Turtles occur in relatively flood-prone streams over large portions of their range. Although Wood Turtles are distributed across large portions of the northeastern United States and southeastern Canada (Ernst and Lovich 2009), high susceptibility to flooding could be an important reason why they are rare in or absent from high-relief, mountainous regions (although the lack of suitable riparian habitat and climatic variables are also likely significant limiting agents for Wood Turtles in northerly regions, e.g., Compton 1999). Because Wood Turtles overwinter underwater (Ernst and Lovich 2009), they may be limited to less flood-prone streams and stream segments than some other stream-dwelling turtles, such as *E. marmorata* and *K. sonoriense*, which are able to hibernate or aestivate on land (Rathbun et al. 2002; Ligon and Stones 2003; Ernst and Lovich 2009).

In this paper, we examine the effect of severe floods on adult Wood Turtles living in a stream system in Massachusetts. Based on simple models of floods in



New England and preliminary observations of the species, we hypothesize that regular displacement of individual Wood Turtles will occur primarily in mountainous, relatively high-gradient streams, and we predict that surviving Wood Turtles displaced by flooding will influence the reproductive ecology of the downstream site by mating with local Wood Turtles and/or nesting at the downstream site. Because of their demonstrated homing ability, we predict that the majority of Wood Turtles will attempt to return to their upstream location if they survive the initial displacement. Finally, we predict that Wood Turtles in mountainous areas will select relatively low-gradient streams, an adaptation to minimize being displaced by flooding during hibernation.

### Study Area

Surveys for adult Wood Turtles were conducted at 22 separate sites in western Massachusetts and central New Hampshire. Five sites in the same watershed in Franklin County, Massachusetts ("Franklin County Sites," denoted Sites A through E; exact localities are withheld for conservation purposes; Table 1; Figure 1), were studied intensively because the majority of displacement caused by flooding occurred there. We have limited most of our assessment to those sites, although the remaining 17 sites are used for comparative purposes.

The Franklin County sites consist of four sites (B through E) along 23 km of stream in one tributary basin and the main stem and a single site (Site A) on a neighboring tributary (Figure 1). The Franklin County sites range in elevation from 41 to 268 m. The watershed of streams and rivers ranged from 281 ha to ~47 000 ha, and the width ranged from approximately 5 m to 50 m (Table 1). The stream on which all sites are centered flows through a generally agri-forested landscape (Saumure et al. 2007), with some sites being almost entirely forested and others consisting largely of mixed agricultural fields and forest (Table 1). In general, the five Franklin County sites are more heavily forested than the remaining 17 sites, and one (Site D) is largely situated in a narrow valley. While the Franklin County sites exhibit a relatively wide range of 100-m scale stream gradient from 0 to 5%, the average stream gradient at these sites was 1.58%, much higher than the average stream gradient of the remaining 17 sites (0.49%) (Jones 2009).

### Methods

#### Field Surveys and Radiotelemetry

We conducted surveys for Wood Turtles at daily to weekly intervals from April to November 2004; March to November 2005-07; and March to July 2008. Wood Turtles were located by searching stream banks, log-jams, undercut banks, and streamside vegetation, following a protocol similar to that described by Compton et al. (2002), Arvisais et al. (2002), Saumure (2004),

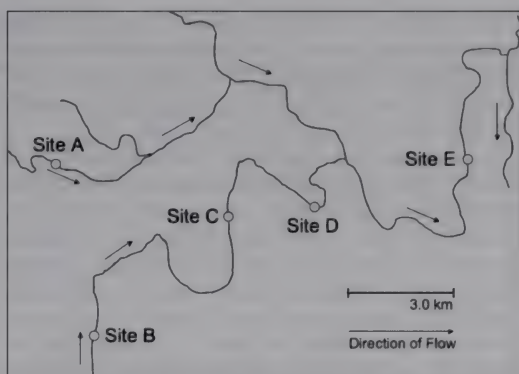


FIGURE 1. Primary Wood Turtle (*Glyptemys insculpta*) study area in Franklin County, Massachusetts, USA, showing approximate configuration of study sites.

and Saumure et al. (2007). Turtles were sexed (Ernst and Lovich 2009), approximately aged by counting growth rings on the left abdominal scute or, if the scute was partially to mostly worn, by estimating shell wear (Jones 2009). Wood Turtles older than one year were individually marked by notching the marginal scutes (Ernst et al. 1974), and all Wood Turtles were digitally photographed as a secondary means of identification. Seven measurements of carapace and plastron, including straight-carapace length (SCL), were taken to the nearest 0.25 mm using dial calipers (Jones 2009). Wood Turtles were classified as juveniles if they had visible new growth at the plastral midline (see Stickel 1978) and fewer than 9 lines of arrested growth (LAG).

Radio transmitters (MBFT-6, Lotek Wireless, Newmarket, Ontario; R2020, Advanced Telemetry Systems, Isanti, MN) were attached to a total of 170 Wood Turtles at 22 sites using orthodontic acrylic resin (BioCryl Resin, Great Lakes Orthodontics, Tonawanda, NY) (see Compton 1999). Of these, 38 radio transmitters were placed on turtles at the five Franklin County sites. Wood Turtles with body mass < 600 g were not equipped with transmitters to ensure that the weight of the transmitter (encased in acrylic) would not exceed ~3% of turtle body mass. We placed transmitters on an approximately equal number of males and females at each site. Wood Turtles with transmitters were located by radiotelemetry between one and three times per week from the initial capture date until November of each year and beginning again in May the following year. For analysis purposes, we defined a complete turtle-year as consisting of > 25 radio locations, collected at a minimum of weekly intervals, over the entire active season.

Locations of Wood Turtles were mapped in the field using handheld GPS (12-channel Etrex, Garmin Inc., Olathe, Kansas, USA) and entered into a Geographic Information System (GIS; ArcMap, ArcView 3.2a and Spatial Analyst, ESRI, Redlands, California,

USA). Distances between locations were calculated using Microsoft Excel v. 11.5.1 (Microsoft Corporation, Redmond, Washington, USA) and ArcMap. Terrain and stream geomorphology data for each study site were derived using ArcMap.

Wood Turtles with transmitters were considered "displaced" if they appeared more than 1.4 km downstream of the limit of all previous observations immediately following a flood event. This threshold downstream distance was based on the 75th percentile "stream home range" (the total length of stream used in one year) of all radio-tracked Wood Turtles. Downstream movement is not direct evidence of displacement by flooding, and defining "displacement" is difficult because Wood Turtles regularly move large distances up- or downstream; for this reason, a heavy emphasis was placed on context. For example, following floods, many displaced Wood Turtles exhibited fresh injuries consistent with long transport over rocks, including broken marginal bone, broken limbs, damaged tails, and missing keratin.

#### *Stream Flow Analysis*

U.S. Geological Survey stream flow data (USGS 2008\*) from one of the five Franklin County sites (Site C) were used to examine the magnitude of floods and to relate flood volume to observed displacement of Wood Turtles. Data from this gage were monitored remotely via the Internet from the University of Massachusetts Amherst, about 10 miles away, during most major rain events, so that Wood Turtles could be checked by radiotelemetry during or following the flood. Stream flow data from this site are collected at 15-min intervals and daily averages computed. Stream flow data are reported by the U.S. Geological Survey in cubic feet per second (cfs), but here we have reported flow measurements in SI units ( $\text{m}^3$  per second,  $\text{m}^3/\text{s}$ ).

We divided the average daily average stream flows associated with observed displacement by the annual daily average stream flow to derive a ratio for the purpose of identifying potential displacing events outside of the study area and study period. This ratio was used to evaluate historic conditions at this site, and to evaluate the possible prevalence of displacing floods at other sites in Massachusetts. By this measure, in our study system, a "displacing flood" occurs when daily flows exceed 14.5 times the average daily flow.

To assess how anomalous the study drainage might be and how extensively floods affect other Wood Turtle populations in the region, we analyzed stream flow records from 11 other streams in Massachusetts for their relative flood frequency and seasonality. To assess how frequently major floods disrupted each system, we multiplied the mean daily flow for each stream by 14.5, the multiplier associated with displacement at the Franklin County sites. We then counted how many events that met that criterion had occurred during the gaging history and the number of these events that occurred well within the active season for Wood Turtles

(May to September), when Wood Turtles are largely terrestrial, as opposed to the "aquatic" season (October to April).

#### *Analysis of Stream Gradient in Habitat Selected by Wood Turtles*

Because of the role played by stream gradient in the magnitude of seasonal floods (Wong 1963) and our hypothesis that the severity of flooding limits the local distribution of Wood Turtles in some mountainous areas, we examined the influence of stream gradient on the distribution of Wood Turtles at two scales in Massachusetts. Using digital terrain models (DTMs) in ArcMap, "home range" stream gradient values were derived for the continuous length of stream used by each of 110 radio-equipped Wood Turtles for which we had obtained an entire season of movement data. For comparison, we also estimated stream gradient of a paired, random, non-overlapping stream segment of a random length between 352 and 3520 m (the 25th and 95th percentile of all observed stream-based home range lengths from 2004 and 2005). The differences in means between the "used" and "random" stream segments were compared using a paired, two-tailed *t*-test.

#### **Results**

A total of 170 Wood Turtles were radio-tracked at 22 sites in Massachusetts and New Hampshire. Thirty-eight Wood Turtles were radio-tracked in Franklin County at Sites A–E, where the phenomenon of displacement by flooding was studied.

During our four-year study, seven disruptive floods occurred in the Franklin County watershed that resulted in the downstream displacement of adult Wood Turtles. The minimum average daily flow resulting in displacement was  $24.35 \text{ m}^3/\text{s}$  (14.5 times average daily flow), including a record flood on 9 October 2005, when peak flow at Site C exceeded  $248 \text{ m}^3/\text{s}$  (USGS 2008\*). Displacing floods occurred in January, March, April, and October (Table 2). Peak 15-minute stream flow during these floods ranged from  $64.17 \text{ m}^3/\text{s}$  to  $248.40 \text{ m}^3/\text{s}$  (Table 2). During each flood that exceeded  $24.35 \text{ m}^3/\text{s}$ , between one and four Wood Turtles carrying transmitters were displaced from their overwintering site and transported downstream (Table 2).

During 42 years of record (June 1966 – July 2008), 21 displacing floods exceeding  $24.35 \text{ m}^3/\text{s}$  occurred between October and April (when Wood Turtles are aquatic and most susceptible to displacement) (USGS 2008\*). This equals an average annual winter displacing flood rate of 0.50 floods per year, considerably lower than the frequency observed during our study, 1.67 displacing floods per year. According to our method of determining "displacing floods" (multiplying average daily flows by 14.5), this site is in the 90th percentile of gaged streams in western Massachusetts (Table 3).

A minimum of 12 Wood Turtles at the Franklin County sites were displaced a total of 17 times, and



TABLE 2. The number and date of floods at our field sites in Franklin County, Massachusetts, USA, that met or exceeded 24.85 m<sup>3</sup>/s mean daily flow between 8 April 2004 and 22 July 2008 at the U.S. Geological Survey stream gage near Site C.

Date	Time of peak stream flow	Mean daily flow (m <sup>3</sup> /s)	Maximum daily flow (m <sup>3</sup> /s)	Number of displaced turtles equipped with transmitters	Proportion of turtles with transmitters displaced	Number of additional displaced turtles
3 April 2005	0400	35.82	81.89	3	0.19	0
24 April 2005	no data	26.45	no data	1	0.05	0
9 October 2005	1515	68.10	248.40	3	0.13	0
15 October 2005	0115	29.48	64.17	2	0.09	0
18 January 2006	no data	26.05	no data	1	0.11	0
16 April 2007	1000	89.99	205.13	3	1.00	3
8 March 2008	1845	24.35	72.52	1	0.17	0

3 of these turtles were displaced multiple times. Nine Wood Turtles were carrying transmitters when they were displaced or buried during floods, and 3 additional Wood Turtles, which had been radiotracked earlier in the study, were captured and again equipped with transmitters following floods. We identified these 3 animals by their marginal notches and confirmed their identity using the digital photographs taken upon their initial capture. Although at least 12 Wood Turtles (9 equipped with transmitters at the time of displacement plus 3 Wood Turtles previously radio-tracked) were displaced during flooding during this study, only 9 were located at least once following displacement. Known displacement distances for these ranged from 1.4 to 16.8 km and averaged 4.8 km. We observed an average displacement rate per disruptive flood of 25% in our sample of Wood Turtles equipped with transmitters. By averaging the proportion of Wood Turtles displaced in each flood and multiplying it by the average number of displacing floods per year (1.67, see above), we extrapolate an average annual displacement rate at the Franklin County sites during the study period of 41.5% of the adult population. This may be an overestimate, in part because we have included a potentially anomalous event in which 3 Wood Turtles carrying transmitters were displaced on 16 April 2007, representing all of the Wood Turtles equipped with transmitters in the basin at that time. Excluding the flood on 16 April 2007 on the grounds of small sample size ( $n = 3$ ), we estimate an average annual displacement rate of 20.6%.

Of the four adult female Wood Turtles recovered following displacement and radio-tracked during the following nesting cycle, only one became gravid. The displaced Wood Turtle that nested following displacement in 2005 (#75) did not nest in 2006, following a much larger displacement. This annual nesting rate of about 25% observed in displaced Wood Turtles is substantially lower than the overall annual nesting rate observed in western Massachusetts (71%: Jones 2009).

No displaced Wood Turtles were observed copulating while at a downstream (i.e., displacement) location.

When Wood Turtles ended up in deep-walled ravines, such as at Site D, animals without exception sought high ground ( $n = 3$ ), moving to hayfields and clearcuts more than 200 m from the stream and up to 110 m above it.

Following displacement by a flood, Wood Turtles were recovered in segments of low-gradient stream, adjacent to deep pools in large rivers, behind Beaver (*Castor canadensis*) dams that were not destroyed by the flood, and behind defunct dams. Three of nine (33%) displaced Wood Turtles were recovered above a single, defunct dam dating from the 1890s.

#### Additional Wood Turtles Possibly Displaced

It is worthy of note that a major flood (mean daily discharge = 30.02 m<sup>3</sup>/s) occurred on 1 April 2004, only days prior to the start of initial surveys for this project. We suspect that several Wood Turtles initially captured in the spring of 2004 had been displaced in a recent flood, either the 1 April 2004 flood noted above or an earlier event. These animals exhibited aggregate symptoms and behaviors similar to the 12 animals known to have been displaced. We have broadly classed these symptoms and behaviors as follows: (1) fresh injuries to shell, limbs, or tail, typically in the form of cracked or chipped marginal bone and missing keratin; (2) sudden large movement upstream, sometimes followed by year(s) of sedentary behavior at an upstream site; and (3) anomalous overland movement of extreme length that is difficult to record because the animal suddenly moves out of radiotelemetry range in an unpredictable direction. At least 11 additional Wood Turtles exhibited a sufficient combination of these physical or behavioral symptoms to lead us to suspect that some portion of them had been displaced prior to being equipped with transmitters. Still, this is a cautionary assessment, because for each symptom listed above, several other plausible explanations exist.

#### Mortality During and After Floods

Wood Turtles displaced by flooding typically survived the initial displacement; however, we found evidence that mortality rates resulting from infection, mammal attacks, and unknown causes are higher in

TABLE 3. Using 14.5 times average daily flow as a threshold capable of displacing overwintering Wood Turtles (derived from observations at sites in Franklin County, Massachusetts, USA), we estimated the number and frequency of comparable floods on 12 streams in western Massachusetts, USA.

River	Area (square miles)	Gaged time (years)	Average daily flow (m <sup>3</sup> /s)	Inferred flood threshold (m <sup>3</sup> /s)	No. of floods October-- April	No. of floods May-- September	Winter flood frequency	Summer flood frequency	Annual flood frequency
Deerfield River	361	95.1	25.73	373.12	9	5	0.09	0.05	0.15
North River	89	68.7	5.45	78.99	29	5	0.42	0.07	0.50
Site C	24.1	42.0	1.57	22.83	21	5	0.50	0.12	0.62
Green River	41.4	40.8	2.62	38.09	13	2	0.32	0.05	0.37
Mill River at Whately	20.6	1.8	1.07	15.52	1	0	0.55	0.00	0.55
Mill River at Northampton	52.6	69.7	2.85	41.31	25	6	0.36	0.09	0.44
Westfield River (east branch)	161	31.0	9.15	132.65	10	4	0.32	0.13	0.45
Westfield River (main branch)	52.7	54.0	2.93	42.29	26	5	0.48	0.09	0.57
Westfield River (west branch)	94	72.8	5.54	80.37	32	12	0.44	0.16	0.60
Housatonic River (east branch)	57.6	72.3	3.07	44.55	20	4	0.28	0.06	0.33
Housatonic River (tributary of the Housatonic River)	51	19.0	2.25	32.60	5	0	0.26	0.00	0.26
Green River (tributary of the Hoosic River)	42.6	68.8	2.40	34.86	7	1	0.10	0.01	0.12

displaced Wood Turtles than in non-displaced Wood Turtles.

Of the nine Wood Turtles that were located and radio-tracked during the year following their displacement, three (33%) died within one year of displacement. Of these, two Wood Turtles (female #66 and female #396) were apparently killed by mammals 74 and 42 days following displacement, respectively. One male (#222) died of unknown causes during the winter following displacement, and his decomposed remains were recovered on a riverbank the following spring. It is noteworthy that five Wood Turtles (two of which had been displaced to Site D the previous year) were transported from sites C and D over a dam 19 m high and concurrently lost their transmitters; the post-displacement mortality rate outlined above is conservative because three of the Wood Turtles displaced over the dam have no post-displacement radiolocations (F59, F2000, M1000) and cannot be included in the sample.

The mortality rate of the nine radio-tracked displaced Wood Turtles (3 of 9; 33%) in the year following displacement is significantly higher than that observed in the first year of radiotelemetry of the 158 non-displaced Wood Turtles (11 of 158; 7%) using a Fisher exact test ( $P = 0.0294$ ) (Quinn and Keough 2002).

Homing

Of the nine Wood Turtles radio-tracked the year following displacement, three clearly initiated a return to their original location, and two of those successfully reached their original home range within one year. Two of the homing female Wood Turtles (#75 and #66) covered meandering distances of 3.5 and 1.2 km along the stream corridor (e.g., Figure 2), and one (#61) returned largely overland. This Wood Turtle successfully homed a straight-line distance of 2.5 km (meandering distance of 3.7 km) in 47 days (Figure 3). One displaced male, #107, was displaced from Site B to Site C, and subsequently displaced to Site D, without initiating a return upstream. Another male (#276), displaced from Site A to Site B, subsequently walked overland to Site C, the opposite direction from his observed origin.

Stream Gradient Analysis

Individual Wood Turtles throughout the Franklin County sites occupied stream home ranges with channel gradient significantly lower than available (paired two-tailed  $t$  test, mean used = 0.58%, mean random = 1.27%,  $n = 38$ ;  $P = 0.0007$ ;  $t$  Stat = -3.71). Wood Turtles at our remaining sites in Massachusetts were not associated with significantly lower stream gradient than that generally available (mean used = 0.36%, mean random = 0.49%,  $n = 72$ ,  $P = 0.2124$ ;  $t$  Stat = -1.258). Across sites, 91% of Wood Turtle home ranges were associated with stream gradient < 1%.

Discussion

Our findings have several implications for the conservation of Wood Turtles in New England, and they



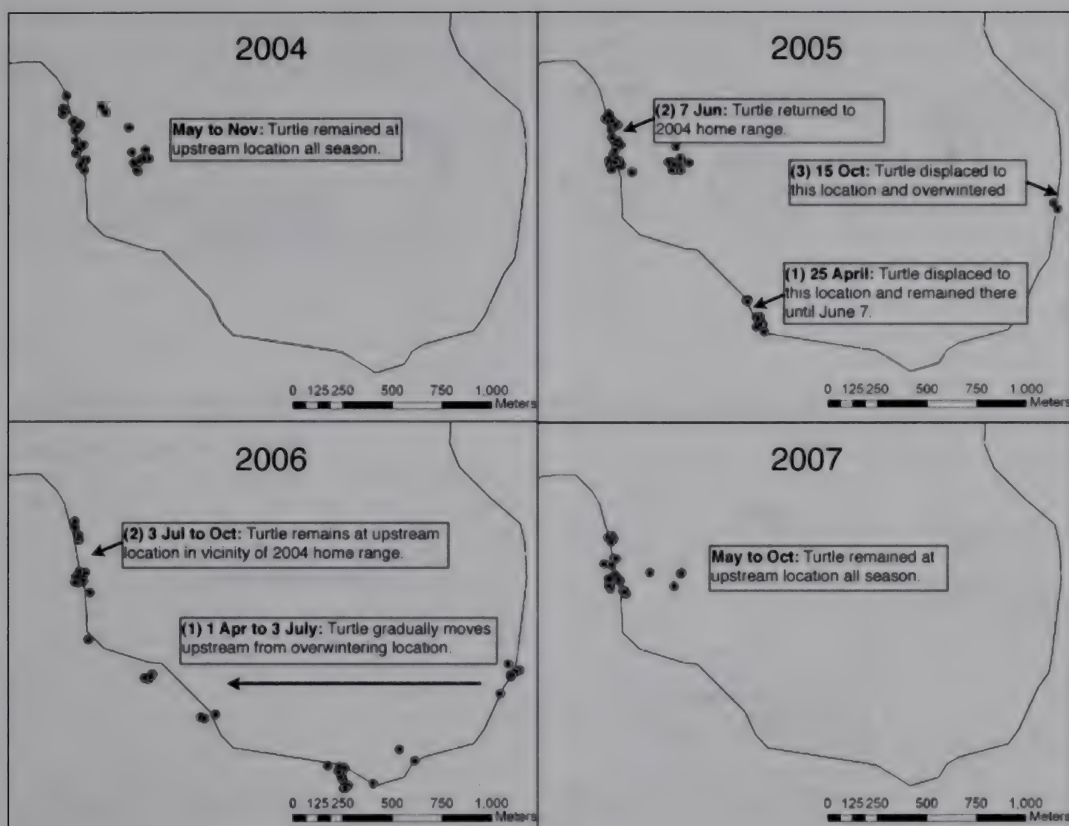


FIGURE 2. Annual home ranges of adult Wood Turtle (*Glyptemys insculpta*) female #75 at the upstream portion of Site C, Franklin County, Massachusetts, USA, illustrating displacement events in 2005 and 2006 and return to original home range via the stream corridor.

may be applicable in some instances to the conservation of other riverine turtle species. Seasonal floods are an example of a stochastic environmental disturbance that clearly is capable of displacing adult Wood Turtles on a relatively frequent basis in our study area, and this flooding appears to exert a negative influence on the local population of Wood Turtles. While displacement by flooding may influence genetic structure within and between watersheds by linking populations that are not behaviorally connected and may represent an important dispersal and/or connectivity mechanism in unfragmented systems, displacement by flooding can also result in Wood Turtles being transported to unsuitable, atypical, unprotected or fragmented habitats. Although we note that caution should be used in artificially characterizing habitats as "fragmented" (see McIntyre and Hobbs 1999), we suggest that displacement from relatively unfragmented sites to more fragmented sites may mean that floods today have the potential to exert a stronger negative influence on Wood Turtle populations than prior to extensive urbanization.

Current projections indicate that the North American climate is becoming increasingly variable, meaning that there may be more pronounced wet and dry years (Watterson 2005; Morris et al. 2008), and also that precipitation will increase overall in the northeastern United States (Meehl et al. 2005). Together, these projections suggest that floods in the northeast will become more frequent and more severe. Agricultural and residential development within the watershed has decreased the resiliency of the landscape to extreme precipitation events (DeNormandie et al. 2009\*), but it is not clear whether the local landscape is becoming more or less resilient to heavy precipitation. Generally, the region is experiencing a reforestation trend and Beavers have returned after a 150-year absence. Beavers may improve landscape resiliency to increased precipitation by creating large wetlands (Jackson and Decker 1995\*). However, forest and fields continue to be converted to development (DeNormandie et al. 2009\*), and stream bank hardening (riprap or concrete retaining walls) remains a common solution to flood

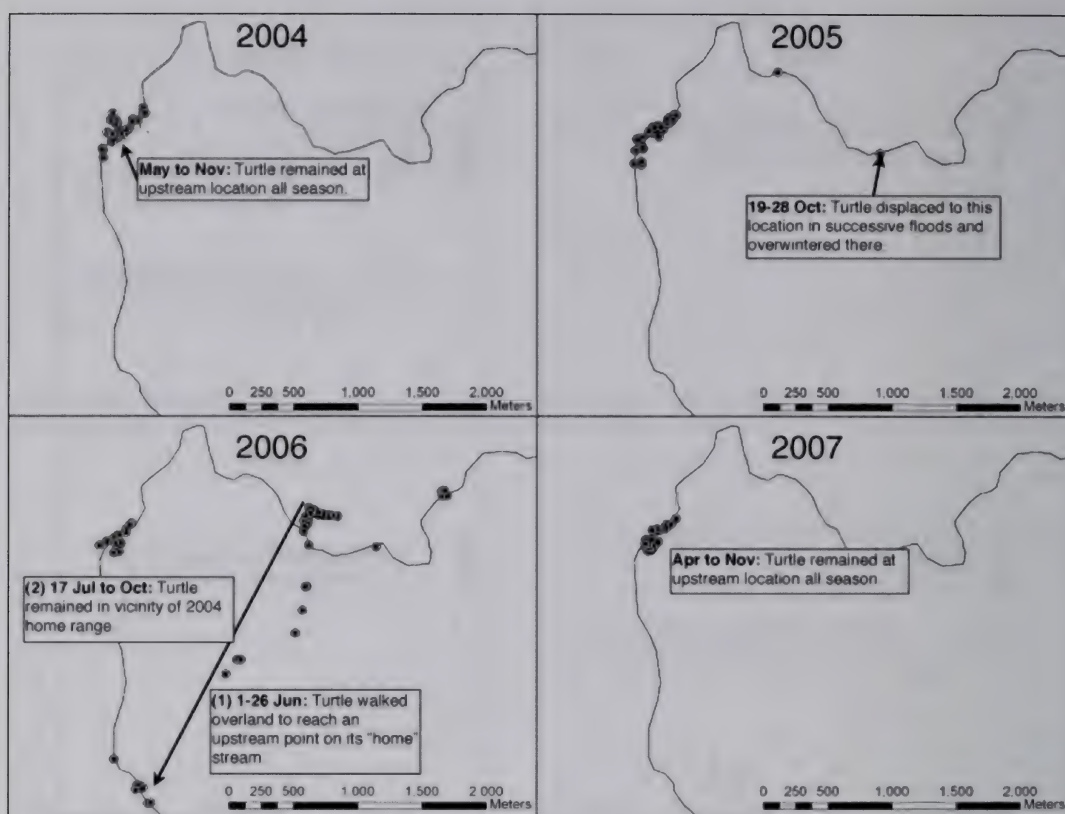


FIGURE 3. Annual home ranges of subadult Wood Turtle (*Glyptemys insculpta*) female #61 at Site C, Franklin County, Massachusetts, USA, in 2004 and 2005, at Site D in 2006, and at Site C in 2007. This illustrates the Wood Turtle's displacement from Site C to Site D in the fall of 2005, a subsequent overland movement to the upstream portion of Site C in the summer of 2006, and subsequent downstream movement to original home range in summer 2006.

damage, potentially increasing the severity of future floods. Combined, increased precipitation is likely to result in larger floods that exert a greater impact on Wood Turtle populations through displacement of individuals.

Increasing flood severity in the New England region could exert greater pressure on Wood Turtle populations by increasing the frequency with which Wood Turtles are displaced. Even relatively remote populations that are apparently not affected by common sources of adult mortality such as road kill (Jones 2009) or agricultural activities (Saumure et al. 2007; Jones 2009) may be negatively affected by an existing or increasing flood regime. Displacement by flooding represents a hidden or cryptic source of mortality that is difficult to monitor, but which may influence population dynamics.

Several Wood Turtles in our study population exhibited the ability to return home following natural displacement, although most were unable to do so within the time we observed them, partly resulting from elevated mortality associated with displacement. At least one displaced Wood Turtle in our study returned

to her initial capture site by traveling over land, indicating that Wood Turtles are not constrained to river corridors when returning home after floods, although they may preferentially use them as corridors (see Barzilay 1980). Wood Turtles displaced great distances downstream may be exposed to roads, new habitat features, and unfamiliar Wood Turtle populations while homing, especially if they cross over land. It is possible that high-quality habitat encountered while homing may be later incorporated into the home range. Overall, the average distance that Wood Turtles in our study were displaced (4.8 km) is not greatly different from the distances traveled by homing Wood Turtles reported by Carroll and Ehrenfeld (1978) and Barzilay (1980). Barzilay (1980) proposed that olfaction and familiarity with visual landmarks are more important to homing navigation than geomagnetic or solar cues; our research indicates that the physical stress associated with displacement, which appears to elevate mortality rates, also may decrease homing ability.

In our study, a large dam appeared to play a role in stopping the downstream transport of displaced Wood Turtles. In similar situations (relatively flood-prone



streams with a Wood Turtle population), the effects of dam removal on up- and downstream Wood Turtle populations should be evaluated during re-licensing and long-term planning.

Within a small area, streams and rivers vary in the degree to which they are prone to flooding. Wood Turtle populations in less flood-prone streams may represent more predictable and stable conservation opportunities because individuals are probably displaced off-site at a lower rate. Because management and conservation opportunities for Wood Turtles are often constrained to a relatively small scale (i.e., smaller than the whole watershed), it is important for land managers to consider in their planning the potential effects of displacement caused by flooding.

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# Nest Success and Duckling Survival of Greater Scaup, *Aythya marila*, at Grassy Island, New Brunswick

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Nesting biology and duckling survival of Greater Scaup (*Aythya marila*) at Grassy Island on the Saint John River in southern New Brunswick were compared between 1995 and 1996. Grassy Island in New Brunswick is an area that is notably removed from other scaup breeding areas, being located farther south from main breeding areas in North America. The Mayfield estimates of nest success were 61% and 21% in 1995 and 1996, respectively. Mean daily survival rates were 0.99 in 1995 and 0.96 in 1996 and were significantly different ( $t = 4.86$ ,  $P < 0.001$ ). Duckling survival was estimated to range from 38 to 54% in 1995, and was 8% in 1996. The lower breeding success in 1996 may have been due to factors associated with decreased temperatures and increased precipitation, but the fact that the breeding location is atypical to other Greater Scaup breeding areas should not be overlooked.

**Key Words:** Greater Scaup, *Aythya marila*, nest success, duckling survival, New Brunswick.

Duckling mortality is usually greatest in the first one to two weeks post-hatch and can influence duckling recruitment. Variation in nesting success of Mallards (*Anas platyrhynchos*) influenced changes in annual population size more than any other criterion (Hoekman et al. 2002). Additionally, Flint et al. (2006) found that scaup productivity explained more variation in population trends than adult survival. Therefore, relatively small changes in nesting success have the ability to result in large decreases in recruitment. Identifying reasons behind failed nest attempts throughout the range of Greater Scaup (*Aythya marila*) is important, particularly in isolated breeding areas that are not well studied (Austin et al. 2000).

Duckling mortality has been associated with poor weather (Blums et al. 2002; Jonsson et al. 2009). Ducklings of most species have poor thermoregulatory capabilities and are vulnerable to cold and wet situations. Weather may indirectly increase mortality rates of ducklings by reducing their ability to feed (Hilden 1964) or by altering their behavior, possibly resulting in an increased risk of predation (Mendenhall and Milne 1985). During our study in 1996, the late incubation, hatching and early brood rearing periods (July through early August) of Greater Scaup nesting at Grassy Island, New Brunswick were significantly cooler and wetter than 1995 (Smith 1999). Precipitation in 1996 was more than double the observed value in 1995 (National Climate Data and Information Archive 2008). Concurrent with the higher precipitation (Figure 1)

were rising water levels (approximately 1 m higher in 1996) which flooded nests and altered brood rearing habitat (Smith 1999). We examine the nesting biology and duckling survival of Greater Scaup in this far-removed southernmost breeding area (McAlpine et al. 1988) and discuss how environmental attributes may have influenced their nesting success.

## Study Area

The study was conducted on the Saint John River at Oak Point, in southern New Brunswick (45°31'N, 66°05'W). The surrounding area is deltaic in character containing several islands, coves, and extensive beds of aquatic vegetation (Choate 1973\*). River levels fluctuate over 2.5 m seasonally and fluctuations of 6 m have been recorded (Choate 1973\*). Nesting data were collected from Grassy Island (45°31'N, 66°04'W), a low-lying 32 ha island located 0.7 km offshore from Oak Point. Island vegetation was dominated by grasses (*Calamagrostis* spp., *Phalaris* spp.), forbs (predominantly *Lythrum salicaria*), sedges (*Carex* and *Cyperus* spp.), a few small stands of shrubs (*Cornus* and *Alnus* spp.) and trees (*Fraxinus* and *Acer* spp.). The island is submerged annually during spring flooding (A. Smith, personal observation). Common Terns (*Sterna hirundo*), Ring-billed Gulls (*Larus delawarensis*) and Great Black-backed Gulls (*L. marinus*) also nest on the island. This location is removed and farther south of the larger breeding area for Greater Scaup.

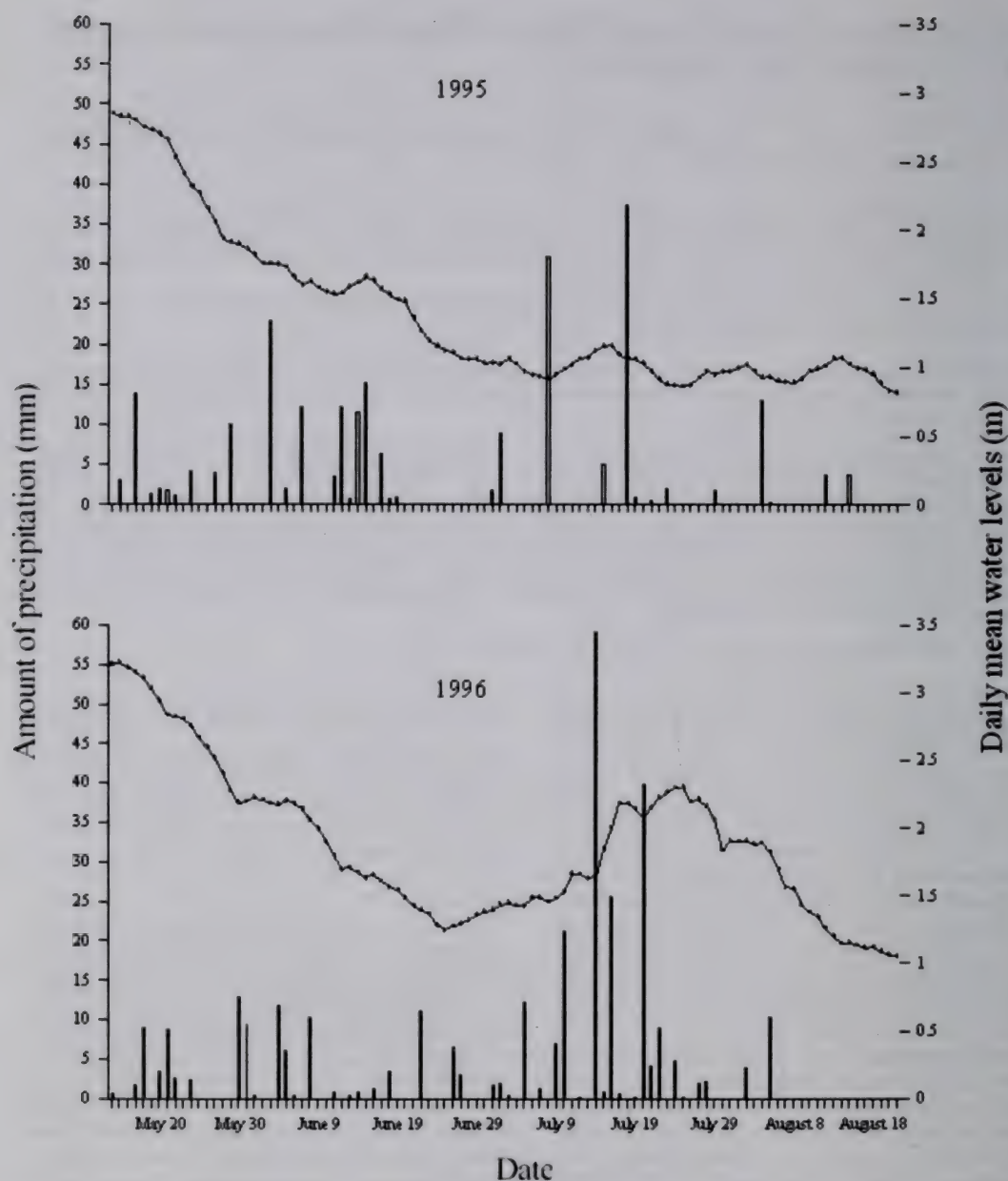


FIGURE 1: Precipitation (bars) and water levels (lines) at Oak Point, New Brunswick during the 1995 and 1996 Greater Scaup breeding seasons.

## Methods

Scaup nest sites were found by systematic searches conducted by 5 to 10 people during mid-morning (Gloutney et al. 1993), on four dates in 1995 (15, 22, 27 June and 6 July), three dates in 1996 (18, 25 June and 3 July) and opportunistically when conducting other field work. Nests were mapped and relative nest elevation was estimated. All nests were monitored to determine their fate. When females flushed from nests,

researchers covered the eggs with down and other nest material, and placed a string on top of the eggs. If on a subsequent visit the string had not been moved (i.e., indicating that the female had not returned to the nest), it was assumed that the bird had abandoned the nest (Klett et al. 1986). Nest initiation was estimated by backdating from hatch dates or an age estimated by candling; or if found during laying, by counting the number of eggs (assuming one egg laid per day; Weller



TABLE 1. Fate of Greater Scaup nests found on Grassy Island, New Brunswick in 1995 and 1996.

Fate	1995		1996	
	n	%	n	%
Abandoned	22	19.3	41	36
Hatched	61	53.5	32	28.1
Depredated	4	3.5	17	14.9
Flooded	0	0	7	6.1
Abandoned due to researchers <sup>a</sup>	3	2.6	2	1.8
Abandoned or perished due to trapping, marking or radio tagging <sup>b</sup>	14	12.3	13	11.4
Unknown <sup>c</sup>	10	8.8	2	1.8

<sup>a</sup> Nests were abandoned during laying or early incubation, most likely due to nest checking activities.

<sup>b</sup> During 1995, 14 nests were abandoned due to trapping and nasal marking. During 1996, 9 nests were abandoned due to trapping, marking and radio-tagging activities, and 4 hens died during radio-implant operations.

<sup>c</sup> Nests were lost so their fate was unknown.

1956). Incubation was assumed to last 27 days (Johnsgard 1975; Bellrose 1980). Clutch size was defined as the maximum number of eggs observed in a nest. We considered nests with >12 eggs as dump or community nests, and these were excluded from clutch size analysis (Weller et al. 1969). Eggs that did not hatch, and were not thought to be from parasitic laying, were counted as unhatched. No distinction was made between infertile and unviable eggs.

Nest success was estimated using the modified Mayfield method, and daily survival rates were compared using a t-test (Mayfield 1961, 1975; Johnson 1979; Klett et al. 1986). Dates of nest abandonment were rarely known so they were estimated by adding the number of days of probable exposure as determined by the modified Mayfield method, to the last date the nest was observed to be viable (Klett et al. 1986). Probable exposure equaled half of the interval between the last date the nest was viable, and the date when nest fate was determined or the estimated hatch date, whichever was less. If the interval was > 14 days, it was multiplied by 0.4 instead of 0.5 (Johnson 1979). Nest age at abandonment was determined by subtracting the date of nest initiation from the date of abandonment. Nests that were destroyed due to flooding were considered separately from abandoned nests.

The frequencies of hatching, abandonment and predation were compared between years using a chi-square test of independence. Between-year differences in variables were tested with Wilcoxon rank-sum test. Tests of skewness were used to compare the distribution of nest-initiation dates, hatch dates and abandonment dates, and nest age at abandonment between years (Snedecor and Cochran 1967). Nests of unknown fate or failed due to researcher activities were not included in analyses of abandoned nests.

In 1995, nine brood surveys were conducted by boat between 13 and 31 August. In 1996, 6 brood surveys were conducted by boat between 13 and 21 August. All surveys were conducted during daylight hours. A regular route was followed and ducklings counted

from vantage points at known brood-rearing areas and opportunistically. Brood surveys were also conducted from airplane during mid-morning on 28 August 1995 and 16 August 1996. When a brood was observed, it was circled until species, and number of adults and young, could be verified by two observers.

During 1996, seven nests were found on Rush (45°30'N, 66°05'W) and Hog (45°33'N, 66°01'W) Islands located near Grassy Island. Two of the seven nests hatched a total of 12 eggs. Those islands were not searched in 1995. To account for duckling production from those islands in 1995, the number of nests found in 1996 (7) was multiplied by median clutch size (9), and percentage of eggs hatched (47%) from nests on Grassy Island in 1995 for an estimated 30 hatched eggs. The two islands were searched only once each so it was likely that some nests were missed. Therefore, these estimates should be considered the minimum production of ducklings.

The ratio of ducklings observed in mid to late August to eggs hatched was used as a rough estimate of duckling survival. A chi-square test was used to compare survival between the two years of the study.

## Results

A total of 114 nests were found on Grassy Island in both 1995 and 1996. The Mayfield estimate of nest success was 61% in 1995 and 21% in 1996. Mean daily survival rates of 0.99 (SE = ±0.003) in 1995 and 0.96 (SE = ±0.005) in 1996 were significantly different ( $t = 4.86$ ,  $P < 0.001$ ). Fewer nests hatched, and more were abandoned and preyed upon in 1996 than expected when compared to 1995 ( $\chi^2 = 22.78$ ,  $P < 0.001$ ; Table 1). The date of abandonment was positively skewed in 1995 ( $P < 0.05$ ), but was negatively skewed in 1996 ( $P < 0.05$ ; Figure 2).

In 1995, 426 eggs hatched on Grassy Island. An estimated minimum hatch of 30 eggs on other islands resulted in a minimum total hatch of 456 eggs. Number of scaup ducklings observed during boat surveys ranged from 70 to 179. A survey conducted on 31

TABLE 2. Some statistics from greater scaup nests found on Grassy Island, New Brunswick in 1995 and 1996.

Characteristic <sup>a</sup>	1995			1996		
	N	Mean	SE	n	Mean	SE
Fall clutch size <sup>b</sup>	99	8.74	0.15	101	8.83	0.17
Unhatched eggs/hatched clutch	60	1.43	0.20	32	1.69	0.34
Relative nest elevation (m)	104	0.86	0.02	114	0.89	0.02
Date of nest initiation <sup>b</sup>	109	June 14	0.78	106	June 16	0.81
Date of nest abandonment	22	July 8	2.64	39	July 11	2.45
Age at nest abandonment	21	20.32	1.95	36	24.46	1.34
Hatch date	60	July 19	0.97	32	July 19	1.18

<sup>a</sup> Differences between years were not significant using a Wilcoxon rank sum test unless indicated.

\*  $p < 0.05$

TABLE 3. Weather conditions in southern New Brunswick during the Greater Scaup breeding season 1995 and 1996.

	1995		1996		Test
	Mean	SE	Mean	SE	
Season (n = 99, 96) <sup>a</sup>					
Mean daily temperature (°C)	16.56	0.38	15.65	0.35	z = -1.91
Mean daily precipitation (mm)	2.43	0.61	3.25	0.85	z = 1.09
Mean daily wind speed (km/hr)	9.65	0.39	11.60	0.55	z = 2.43*
Mean daily water level (m)	1.39	0.06	1.82	0.10	z = 6.21***
Prelaying (n = 14, 14)					
Mean daily temperature (°C)	10.61	0.58	10.64	0.90	t = -0.03
Mean daily precipitation (mm)	2.25	0.97	3.44	1.21	z = -0.10
Mean daily wind speed (km/hr)	9.88	1.22	13.86	1.75	t = -1.87
Mean daily water level (m)	2.56	0.07	2.65	0.08	t = -0.86
Laying (n = 37, 39)					
Mean daily temperature (°C)	15.73	0.47	15.03	0.39	t = 1.15
Mean daily precipitation (mm)	2.96	0.91	2.07	0.59	z = -0.24
Mean daily wind speed (km/hr)	10.03	0.69	12.33	0.73	t = -2.29*
Mean daily water level (m)	1.47	0.05	1.64	0.05	z = -1.34
Early Incubation (n = 29, 25)					
Mean daily temperature (°C)	16.81	0.49	14.79	0.52	t = 2.85**
Mean daily precipitation (mm)	2.14	0.80	1.77	0.67	z = 0.65
Mean daily wind speed (km/hr)	9.93	0.79	12.45	1.00	t = -1.99
Mean daily water level (m)	1.28	0.05	1.45	0.03	z = 2.13*
Late Incubation (n = 29, 25)					
Mean daily temperature (°C)	18.94	0.44	17.37	0.34	t = 2.78**
Mean daily precipitation (mm)	3.17	1.67	7.04	2.92	z = 1.98*
Mean daily wind speed (km/hr)	9.25	0.60	12.18	1.03	z = 2.19*
Mean daily water level (m)	0.98	0.02	1.96	0.07	z = 6.28***
Hatching (n = 31, 26)					
Mean daily temperature (°C)	18.83	0.41	17.28	0.34	t = 2.82**
Mean daily precipitation (mm)	2.96	1.57	6.92	2.81	z = 2.30*
Mean daily wind speed (km/hr)	9.55	0.60	11.98	1.01	z = 1.73
Mean daily water level (m)	0.98	0.01	1.96	0.05	z = 6.45***
Early Brood Rearing (n = 23, 23)					
Mean daily temperature (°C)	18.90	0.46	17.37	0.37	t = 2.59*
Mean daily precipitation (mm)	3.33	2.05	7.65	3.15	z = -2.37*
Mean daily wind speed (km/hr)	9.10	0.74	12.68	1.06	z = -2.44*
Mean daily water level (m)	0.99	0.01	1.97	0.07	z = -5.80***
Late Brood Rearing (n = 23, 22)					
Mean daily temperature (°C)	18.85	0.53	18.17	0.46	t = 0.96
Mean daily precipitation (mm)	0.98	0.59	0.64	0.49	z = -1.03
Mean daily wind speed (km/hr)	9.67	0.72	7.74	0.88	z = -1.98*
Mean daily water level (m)	0.96	0.01	1.44	0.07	z = 5.64***

<sup>a</sup> n is the number of days in the period 1995 and 1996 respectively.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.0001$



August recorded 175 ducklings. A total of 244 ducklings was counted on 28 August 28 in an airplane survey. Duckling survival (based on 456 eggs hatched) ranged from an estimated 38.4% (assuming 175 ducklings survived) to 53.5% (assuming 244 ducklings survived).

In 1996, 226 eggs hatched on Grassy Island plus a minimum of 12 more on other islands for a total of 238. Number of scaup ducklings observed during boat surveys ranged from 2 to 18. Two broods totaling 16 ducklings were observed during an airplane survey on 16 August. Based on their numbers and locations, duckling production in 1996 was estimated to be approximately 20 individuals, representing a survival rate of 8.4 %. Compared to 1995, far fewer ducklings survived to fledging than expected in 1996 ( $\chi^2 = 42.70$ ,  $P < 0.001$ ). The late incubation, hatching and early brood-rearing stages (July through early August) during 1996 were significantly cooler and wetter (Figure 1; Table 3) than 1995 (Smith 1999).

## Discussion

We present information on Greater Scaup nest success and duckling survival at their southernmost breeding location. Duckling survival was lower in 1996 than 1995. The difference in nesting success between 1995 and 1996 was possibly due to cooler temperatures and high precipitation causing high water levels during late incubation and hatching periods in 1996. Seven nests were destroyed by flooding in 1996, and several were observed that had material added to raise them (i.e., cone nests; Hilden 1964). Almost twice as many nests were abandoned in 1996 compared to 1995. In 1996, females may have abandoned their nests late in incubation out of necessity in order to devote more time to feeding and self-maintenance (Korschgen 1977; Ankney and MacInnes 1978; Gloutney and Clark 1991). Other studies have found similar results when studying other duck species during poor weather conditions (Bengtson 1972; Makepeace and Patterson 1980; Mendenhall and Milne 1985; Walker et al. 2005).

The increased mortality of ducklings in 1996 may have been due to decreased foraging opportunities caused by inclement weather. During the first few days of life, diving ducklings generally feed on the surface (Bengtson 1971, 1972; Sugden 1973; Hill and Ellis 1984). Invertebrate production and emergence may have been reduced during 1996 (Sjoberg and Danell 1982; Anderson and Wallace 1984). Furthermore, flooding delayed the growth of emergent bulrush (*Scirpus* spp.) and sedge stands which are used for brood-rearing (A. Smith personal observation). These areas would normally provide shelter and hold invertebrate food during bad weather (Hilden 1964, Sjoberg and Danell 1982). Also, the seeds of sedges can be an important food to Greater Scaup ducklings (Bengtson 1971).

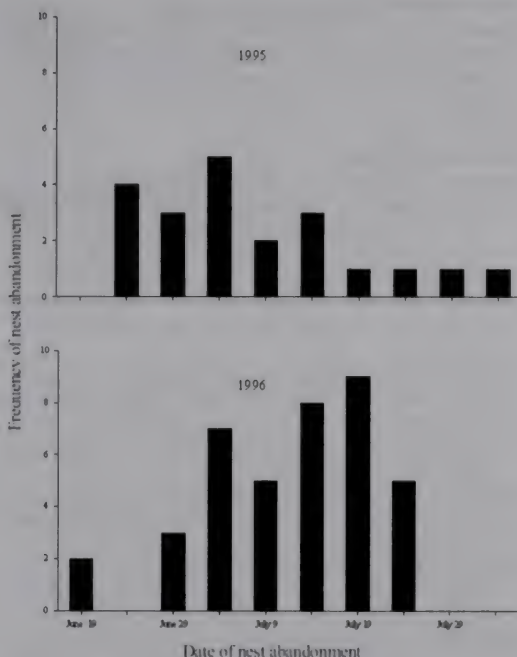


FIGURE 2. Estimated date of nest abandonment by Greater Scaup nesting at Grassy Island, New Brunswick, in 1995 and 1996 (grouped into 5 day periods).

The low temperatures, high precipitation, and high water levels on the Saint John River in 1996 negatively influenced the breeding success of additional bird species. Breeding activity of Yellow Rails (*Coturnicops noveboracensis*) at the Grand Lake Meadows upriver from our study site, ceased after their habitat was flooded (Kehoe et al. 2000). Yellow Warblers (*Dendroica petechia*) suffered decreased nesting success compared to 1995 at several sites in southern New Brunswick (S. Makepeace, New Brunswick Department of Natural Resources and Energy, Fredericton, New Brunswick, unpublished data).

Many species distribution boundaries are dictated by temperature and precipitation. As this study site is the southernmost breeding area for Greater Scaup in North America (McAlpine et al. 1988), determining whether climate change is shifting these boundaries could be an area of future research.

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# Survival and Spatial Ecology of the Snapping Turtle, *Chelydra serpentina*, on the Upper Mississippi River

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We studied the survival and spatial ecology of adult Snapping Turtles (*Chelydra serpentina*) on Pool 8 of the Upper Mississippi River (UMR) during 1997–2001. We captured 597 Snapping Turtles 745 times (333 adult males; 238 adult females; and 26 juveniles) at two study sites; Goose Island, Wisconsin and Lawrence Lake, Minnesota. From this sample, we radio-marked 104 Snapping Turtles of legal harvest size 128 times. Annual survival ranged from 0.857 to 1.000 and averaged 0.944 with Goose Island and Lawrence Lake estimates pooled. Legal harvest was the most important cause of mortality and accounted for 57% of documented deaths. Annual home range size using the Poly-Buff (PB) method averaged 11.13 ha and ranged from 2.20 ha to 37.18 ha. Emergent and rooted-floating aquatic vegetation were used disproportionately more than their availability and 72% of all locations collected during the active period occurred within these habitat types. Overall, radio-marked Snapping Turtles selected hibernacula in the following habitat categories; marshes (38%), main/side channels (28%), backwater sloughs and small ponds (14%), spring areas (10%), small tributary streams (7%), and tertiary channels (3%). Developing conservative, consistent harvest regulations among the states that border the UMR should be a management priority.

**Key Words:** Snapping Turtle, *Chelydra serpentina*, habitat use, hibernacula, home range, radio-telemetry, survival, Upper Mississippi River.

The life history strategy of turtles relies heavily upon adult survival to sustain populations due to generally low reproductive success (Brooks et al. 1988, Obbard 1983). Species such as the Snapping Turtle (*Chelydra serpentina*) and the Spiny Softshell Turtle (*Apalone spinifer*) are particularly vulnerable to population decline due to interest in harvesting adults of these species for human consumption. These species have traditionally been harvested on the Upper Mississippi River, both commercially and non-commercially (for personal use).

Regulations protecting Snapping Turtles on the Wisconsin and Minnesota boundary waters of the Upper Mississippi River have been liberal and inconsistent between the 2 states. Prior to 1997, Wisconsin boundary waters had a continuous season with no bag limits and a minimum 25.4-cm carapace length size limit. In 1997, a turtle season was established which extended from 15 July to 30 November with a possession limit of 10. A slot limit was also established for Snapping Turtles requiring a 30.5-cm minimum and a 40.6-cm maximum carapace length. Prior to 1998, Minnesota boundary waters also had a continuous season that included a bag limit of 3 Snapping Turtles and no limit

for other turtle species. The only size restriction was a 25.4-cm minimum carapace width for Snapping Turtles. In 1998, Minnesota regulations closed the Snapping Turtle season during May and June. All other turtle harvest regulations remained unchanged. All Snapping Turtles taken incidental to licensed commercial fishing operations could also be possessed.

An important factor that influenced these regulation changes was concern expressed by turtle harvesters that turtle populations were declining, particularly Snapping Turtle and softshell turtle populations on the UMR. They also cited the absence of larger individuals in these populations. A review of the existing literature on turtle ecology yielded limited information to allow proper management of turtle populations on the UMR and elsewhere. Basic information on survival, habitat needs, and spatial dynamics is essential to protecting the species and making informed management decisions.

This study focused on adult females because their survival and reproductive role are critical to sustaining populations. Further, we focused on adult females of legal harvest size to provide estimates of survival for females exposed to commercial and non-commercial

harvest on the UMR. Our specific objectives were to (1) estimate survival rates and determine causes of mortality, (2) determine habitat use, (3) identify important hibernacula, and (4) estimate home range size.

### Study Area

We conducted research at two study sites (Goose Island: 708 ha; Lawrence Lake: 384 ha) within navigational Pool 8 (43°43'55"N, 91°14'30"W) on the UMR (Figure 1). Pool 8 is an impoundment on the Upper Mississippi Wildlife and Fish Refuge and is part of the boundary waters between the rugged driftless areas of Wisconsin and Minnesota. This impoundment is 38.8 km in length and encompasses 9000 ha of aquatic habitat. The major tributaries include the Black, Root, and LaCrosse rivers (Burkhardt et al. 2001). Numerous smaller tributaries also enter the impoundment from Wisconsin and Minnesota. Public use is high at both study sites. Primary activities are fishing, hunting, trapping, and boating.

The Goose Island study area occurs on the Wisconsin side of the main channel and is characterized by braided channels, floodplain forests, shallow marshes, and small backwater sloughs. Land cover (with primary species in parentheses) consists of 28% aquatic vegetation including rooted-floating species (American Lotus [*Nelumbo lutea*], White Waterlily [*Nymphaea odorata*]), emergent species (River Bulrush [*Schoenoplectus fluviatilis*], arrowhead spp. [*Sagittaria* spp.]), and submergent species (pondweed spp. [*Potamogeton* spp.], Coontail [*Ceratophyllum demersum*]); 32% open water; 22% floodplain forest (Silver Maple [*Acer saccharinum*], Eastern Cottonwood [*Populus deltoides*], Green Ash [*Fraxinus pennsylvanica*]); 17% wet meadow (Reed Canarygrass [*Phalaris arundinacea*], Rice Cutgrass [*Leersia oryzoides*]; and 1% sand/developed.

Lawrence Lake is a floodplain lake on the Minnesota side of the main channel. Land cover consists of 67% aquatic vegetation; 17% open water; 10% floodplain forest; and 6% wet meadow. Species composition within habitat types is similar to Goose Island though Lawrence Lake frequently produces an abundance of Wild Rice (*Zizania aquatica*).

Climate is characterized by relatively long, cold winters and mild summers. Aquatic habitat is typically ice covered from early-December to mid-March. Ice thickness varies considerably from a thin covering on higher flow areas to 50 cm on backwater areas. Air temperatures range from -32°C to 39°C and average 9.3°C. Annual precipitation averages 91 cm and snowfall averages 106 cm each winter.

### Methods

#### Capture and Handling

During 1997-2001, we captured Snapping Turtles from late-May to mid-August in shallow marsh habitats. Turtles were captured using baited basket traps, hoop nets, and fyke nets. Traps were typically baited with rough fish heads or sardines and were checked

each day. Some turtles were also captured by hand to recover and replace radios that were expected to fail. Physical measurements (carapace length [CL], carapace width, and weight) were collected for all captured Snapping Turtles and sex was determined using the ratio of the pre-cloacal distance to the posterior lobe of the plastron (Mosimann and Bider 1960). Juveniles were defined as turtles with CL < 20 cm (Mosimann and Bider 1960; White and Murphy 1973; Vogt 1981). Each Snapping Turtle >18 cm CL was marked with an aluminum reward band (National Band and Tag Company, Newport, Kentucky) which was attached through a posterior marginal scute (Hammer 1969). Snapping Turtles that were not of legal harvest size were released at the capture site. Those of legal harvest size were transported to the research station to be radio-marked. Mortality-sensitive transmitters (Advanced Telemetry Systems, Isanti, Minnesota) in the 149-150 Mhz range were affixed to the posterior portion of the carapace using fast-setting epoxy. Early in the study, some transmitters were affixed using small stainless-steel bolts and epoxy, but it was determined that epoxy alone provided adequate attachment to the carapace. Radio-marked turtles were held overnight to allow the epoxy to set and released the next morning at the point of capture. Transmitters weighed 30 g and were programmed with duty cycles to allow 2 years of service. Some males of legal harvest size were also radio-marked due to the difficulty in capturing adequate numbers of legal-sized females. Reward payments were made to individuals who recovered or reported marked Snapping Turtles.

#### Monitoring

We located radio-marked turtles with programmable receivers (Advanced Telemetry Systems, Isanti, Minnesota) and 3-element hand-held antennas. Turtle positions were approached slowly using a 4-meter Panther airboat with a 4-cylinder Lycoming engine. The observer was generally able to approach to within 10 m and the position was determined by circling the turtle until signal direction changed significantly. Habitat data were collected and the position was recorded using a GPS unit (Eagle Electronics, Catoosa, Oklahoma). GPS accuracy was checked on a weekly basis using reference coordinates located at the research station. An attempt was made to obtain locations and monitor survival at least once each week. When contact was lost from the water, aerial searches were conducted using a Cessna 180 Skywagon with dual H-element antennas mounted to the struts.

#### Survival

We calculated annual survival on a calendar year basis, using the Kaplan-Meier product limit estimator modified for staggered entry (Pollock et al. 1989). We used a Z-test (Pollock et al. 1989) to compare annual survival by sex and study site. Statistical significance was assessed at  $P < 0.05$ . Turtles surviving  $\leq 14$  days were excluded from the survival analyses.



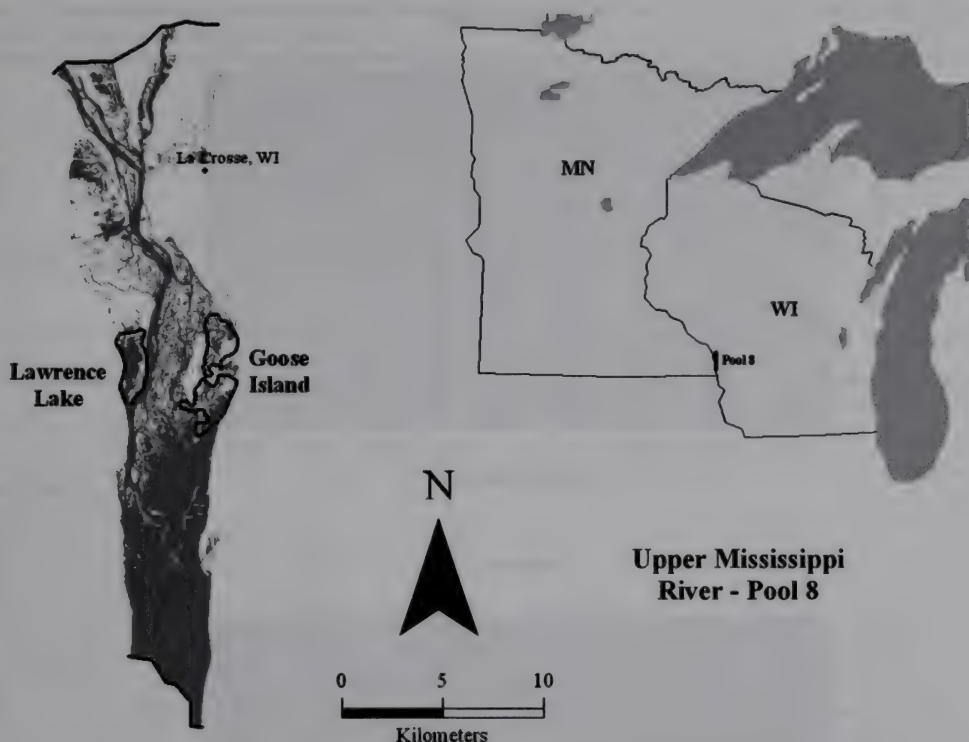


FIGURE 1. Goose Island and Lawrence Lake study areas on Pool 8, Upper Mississippi River, 1997-2001.

#### *Home Range and Habitat Use*

Northing and Easting coordinates collected in the field were integrated into a geographic information system (GIS) to calculate home range sizes for each individual by year, sex, and study site. The criteria used to include individuals for the home range analysis were (1)  $\geq 15$  locations were obtained during the active season, (2) monitoring was initiated no later than 10 June to include movements associated with nesting behavior, and (3) monitoring was continuous to the hibernaculum (established as 1 October).

Two methods were used to calculate home range size. The first method, the PB (Poly-Buffer) method (Hamernick 2001) is similar to the Cluster Analysis method (Edmonds 1998; Carter et al. 1999). The PB method combines overland movements with areas of aquatic activity by measuring the area within a 20-meter path between locations throughout the active season. The Minimum Convex Polygon (MCP) (Mohr 1947, Hooge and Eichenlaub 1997) is a conventional method that has been used extensively in other studies and is included in Table 2 to allow comparison with previous spatial work. Our results are presented using the PB method.

We established seven habitat types to characterize habitats used by Snapping Turtles during the active period: emergent, open water, rooted-floating aquatic,

sand/developed, submergent, wet meadow, and woody terrestrial. These habitat types are part of a larger land cover classification system developed in 2000 by the U.S. Geological Survey, Upper Midwest Environmental Sciences Center, LaCrosse, Wisconsin.

#### *Hibernacula*

Hibernacula were generalized into the following floodplain categories:

- (1) Main Channel: includes main channel, main channel border, and side channels (secondary channels). Channel types are described in detail by Wilcox (1993).
- (2) Tertiary Channel: small floodplain channels  $\leq 30$  m wide.
- (3) Tributary: small spring-fed streams generally  $< 10$  m wide that enter the floodplain from adjacent watersheds.
- (4) Marsh: shallow backwater areas with little or no flow. These areas are characterized by emergent, root-floating, and submerged vegetation.
- (5) Slough/Pond: shallow backwater areas with little or no flow. These are irregularly-shaped water bodies with heavy woody vegetation along shorelines. Sloughs are aquatically connected to other backwater areas and ponds are isolated.
- (6) Spring Area: areas with ground water inflow that typically stay at least partially open during winter.

Distances moved from the geometric center of summer use areas to hibernacula were measured using a GIS. Hibernacula area was defined as the area within 100 m of the hibernaculum.

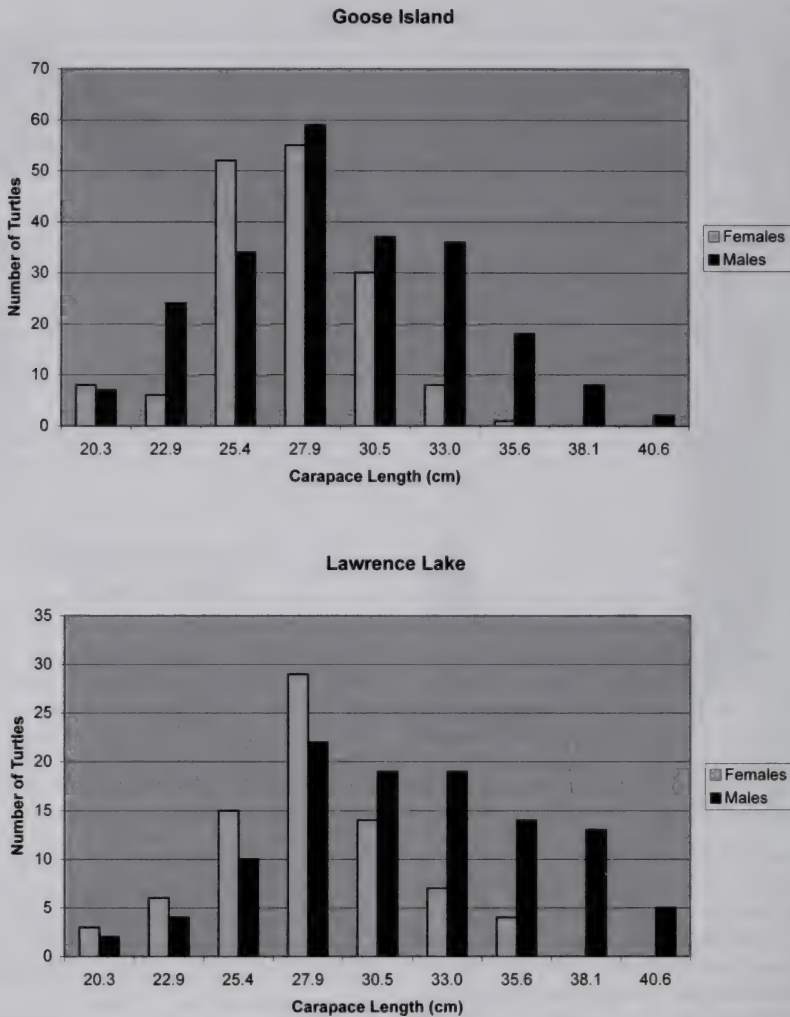


FIGURE 2. Size distribution of initially captured Snapping Turtles at Goose Island and Lawrence Lake study areas on Pool 8, Upper Mississippi River, 1997-2001.

## Results

### *Capture and Handling*

We captured 597 Snapping Turtles 745 times from May 1997 to August 2001. The capture consisted of 333 adult males, 238 adult females, and 26 juveniles. At the Goose Island study area, 1988 trap nights resulted in the capture of 400 Snapping Turtles (225 adult males [56%]; 160 adult females [40%]; 15 juveniles [4%]). We captured 197 Snapping Turtles (108 adult males [55%]; 78 adult females [40%]; 11 juveniles [5%]) in 871 trap nights at the Lawrence Lake study area. The adjusted overall recapture rate was 0.28 because not all captured juveniles were marked (due to their size). Minimum Snapping Turtle density (based

on unique turtles captured) was 0.73/ha at Goose Island and 0.57/ha at Lawrence Lake.

Mean CL of females at Goose Island was 28.2 cm (range = 20.3 – 35.6) and 29.0 cm (range = 20.3 – 36.8) for females at Lawrence Lake. Average body mass of adult females at Goose Island and Lawrence Lake was 4.5 kg (range = 1.4 – 8.2) and 5.1 kg (range = 2.0 – 10.4), respectively. CL of males averaged 30.0 cm (range = 20.3 – 41.4) at Goose Island and 32.3 cm (range = 20.3 – 41.9) at Lawrence Lake. Adult males averaged 5.6 kg (range = 1.4 – 13.6) at Goose Island and 7.2 kg (range = 1.8 – 13.8) at Lawrence Lake.

Twenty-four percent of females and 45% of males were at risk of legal harvest (CL 30.5 cm-40.6 cm) at



TABLE 1. Survival rates of radio-marked snapping turtles (sexes pooled) at Goose Island and Lawrence Lake study areas on Pool 8, Upper Mississippi River, 1997-2000.

Year	Goose Island			Lawrence Lake		
	Survival rate	Standard Error	n <sup>a</sup>	Survival rate	Standard Error	n
1997	1.000	0.000	10	0.938	0.061	16
1998	0.944	0.064	19	0.857	0.065	30
1999	1.000	0.000	14	0.962	0.044	27
2000	0.909	0.097	15	1.000	0.000	22

<sup>a</sup> Maximum number of snapping turtles at risk during period of interest.

TABLE 2. Home range sizes (ha) of radio-marked Snapping Turtles at Goose Island and Lawrence Lake study areas on Pool 8, Upper Mississippi River, 1997-2001.

Study Area Year	Female Home Ranges			Male Home Ranges		
	Poly-Buffer	MCP	n <sup>a</sup>	Poly-Buffer	MCP	n
Goose Island						
1997	—	—	0	—	—	0
1998	14.74	66.83	7	—	—	0
1999	10.71	26.80	9	14.18	38.23	2
2000	13.96	36.55	2	—	—	0
2001	13.27	41.62	1	—	—	0
Overall	12.67	43.36	19	14.18	38.23	2
Lawrence Lake						
1997	7.18	15.08	14	—	—	0
1998	13.54	30.95	12	7.17	12.69	2
1999	11.50	36.69	15	8.60	10.20	2
2000	11.21	29.84	8	—	—	0
2001	11.65	32.24	8	5.09	5.86	1
Overall	10.85	28.59	57	7.33	10.33	5
Totals	11.30	32.28	76	9.29	18.30	7

<sup>a</sup> Number of Snapping Turtle home range values used for analysis.

Goose Island (Figure 2). An important segment of this population occurred just below the minimum legal harvest size (CL 25.4 cm-27.9 cm). Sixty-seven percent of females and 41% of males were in this size class. At Lawrence Lake, 96% of females and 98% of males were at risk of legal harvest.

Radio-marking

We radio-marked 104 Snapping Turtles of legal harvest size during the study period (1997-2001). Forty-five (37 females; 8 males) Snapping Turtles were radio-marked and monitored at Goose Island and 59 (55 females; 4 males) at Lawrence Lake. A total of 128 radios were deployed during the study period.

Survival and Causes of Mortality

We monitored 89 (78 females; 11 males) unique Snapping Turtles of legal harvest size during 1997-2000 to estimate survival rates and identify causes of mortality. Annual survival rates did not differ between females and males ( $P > 0.079$ ) at Goose Island and Lawrence Lake. Pooled (sex) annual survival rates ranged from 0.909 to 1.000 at Goose Island and averaged 0.963 (Table 1). Annual survival rates at Law-

rence Lake ranged from 0.857 to 1.000 and averaged 0.939. Comparison of survival rates between the study areas showed no significant differences except the 1998 Lawrence Lake estimate (0.857) was significantly lower ( $P = 0.014$ ) than the 1997 Goose Island (1.000) and 1999 Goose Island (1.000) estimates. During 1997-2000, annual survival averaged 0.944 with the Goose Island and Lawrence Lake estimates pooled.

Seven recoveries of radio-marked Snapping Turtles were classified as mortalities during 1997-2000; 5 (4 females; 1 male) at Lawrence Lake and 2 (2 males) at Goose Island. Four (57%) of these recoveries were related to harvest activities. One was captured in a gill net at Goose Island, incidental to commercial fishing activities. This turtle was kept by the fisherman for personal consumption. A second was captured in a hoop net at Goose Island by a turtle hunter and also kept for personal consumption. Another Snapping Turtle was "hooked" from an important hibernaculum at Lawrence Lake. Hooking is a harvest technique which uses a rod-like tool with a hook at the end and allows turtle harvesters to locate and remove Snapping Turtles from

hibernacula. The fourth harvest-related recovery was captured through the ice by a fur trapper as he was checking Muskrat, *Ondatra zibethicus*, traps at Lawrence Lake. The last two recoveries were later released by the harvesters, but were classified as harvest-related mortalities because interviews with the harvesters indicated that these animals would have been killed and used for personal consumption had the turtles not been radio-marked.

We were not able to determine cause for three other mortalities that occurred at Lawrence Lake. In two cases, only skeletal parts and the radio were found. Estimated date of death for both was August. One recovery was from a river bulrush mat and the other was adjacent to an active Beaver run. No evidence was found to suggest cause of death. The last documented mortality was an intact carcass found floating on the surface of the marsh during June. We found no external evidence to suggest cause of death. The carcass was submitted for necropsy, but internal decomposition precluded determining cause of death.

#### *Home Range Size and Habitat Use*

Annual home range sizes were calculated using 1933 locations from 52 (47 females; 5 males) Snapping Turtles during 1997-2001. Annual home range size averaged 11.30 ha for females ( $n = 76$ ) and 9.29 ha for males ( $n = 7$ ) with study sites combined (Table 2). Home range size averaged 12.81 ha at Goose Island ( $n = 21$ ) and 10.57 ha at Lawrence Lake ( $n = 62$ ). Overall, annual home range size averaged 11.13 ha ( $n = 83$ ) and ranged from 2.20 ha to 37.18 ha.

Habitat type was recorded for 2622 locations from 91 (81 females; 10 males) unique Snapping Turtles during 1997-2001. Snapping Turtles used emergent vegetation disproportionately more than the area it represented. Forty-four percent of all locations occurred in emergent vegetation while this habitat type comprised only 12% of the total land cover. Rooted-floating aquatic vegetation was also used disproportionately more compared with availability. Twenty-eight percent of all locations were in rooted-floating aquatic vegetation while it represented about 20% of the land cover. All other habitat types had lower use compared with availability: open water (use = 11% vs. availability = 26%), submergent vegetation (use = 7% vs. availability = 10%), wet meadow (use = 8% vs. availability = 13%), and woody terrestrial (use = 2% vs. availability = 18%). Sand and developed areas represented only 1% the land cover and no locations were obtained within these types.

#### *Use of Hibernacula*

We monitored 97 (85 females; 12 males) unique Snapping Turtles during 1997-2001 which resulted in documenting 160 hibernacula occasions. With study sites pooled, average (mean) date of initial movement to hibernacula areas was 28 September ( $n = 139$ ). Fifty-six percent of radio-marked Snapping Turtles

moved to hibernacula areas between 14 September and 7 October, though some turtles began moving to winter sites by August. The average date of hibernacula entry was 26 October ( $n = 149$ ). Fifty-one percent of radio-marked Snapping Turtles exhibited localized behavior between 24 October and 16 November and some individuals were at winter sites by early September. Distances moved from the center of summer use areas to hibernacula ( $n = 103$ ) averaged 621 m and ranged from 30 m to 3226 m.

Nearly half (46%) of radio-marked Snapping Turtles used marsh locations as wintering sites at Goose Island (Figure 3). Typically, these turtles selected sites under dense vegetative mats composed of river bulrush or reed canary grass in or adjacent to muskrat and beaver runs. Other sites were located in dense, residual vegetation (e.g., Lotus and wild rice stubble) on marsh flats with no apparent structure. Eighteen percent of winter sites were in backwater sloughs and nearly all of these turtles were associated with the shoreline and woody structure (e.g., stumps, fallen trees). Abandoned Beaver bank lodges and undercut root systems of large silver maples were particularly attractive to Snapping Turtles in backwater sloughs. Spring areas comprised 16% of winter sites. The most important site was a small woodland pond with a silt substrate and dense beds of submerged vegetation (e.g., Coontail). An influx of well water usually kept a small area of the pond ice-free during winter. The remaining winter sites at Goose Island occurred in tertiary channels (10%) and small tributary streams (10%).

At Lawrence Lake, 43% of documented winter sites were associated with the main channel of the Mississippi River. Nearly all of these turtles (93%) selected hibernacula in a side channel between Lawrence Lake and the main channel of the Mississippi River. Most of these turtles were associated with undercut shorelines and woody structure. The remaining winter sites at Lawrence Lake occurred in marsh (33%), backwater sloughs and floodplain ponds (13%), spring areas (7%), and small tributaries (4%). Microhabitat use was similar to what we observed at Goose Island.

Overall (study sites pooled), winter sites ( $n = 160$ ) occurred in marsh (38%), main/side channel (28%), backwater sloughs and small ponds (14%), spring areas (10%), small tributary streams (7%), and tertiary channels (3%). Water depth at hibernacula averaged 0.4 m and ranged from 0.1 to 1.8 m. Forty-one percent of wintering Snapping Turtles were within 1 meter of a shoreline. Woody structure was observed at 37% of winter sites. Sixteen percent of hibernacula were associated with old Beaver bank lodges, muskrat houses, and active Beaver/Muskrat runs. Radio-marked Snapping Turtles began emerging from hibernacula ( $n = 69$ ) by late March and most (68%) emerged by 17 April. However, some Snapping Turtles remained localized at hibernacula until early May. Movement from hibernacula areas to summer use areas ( $n = 72$ ) began in late



March. Though a few individuals did not leave hibernacula areas until early June, most movement (82%) to summer use areas occurred by 6 May.

## Discussion

Annual survival rates of adult Snapping Turtles averaged 0.944 at Goose Island and Lawrence Lake with estimates pooled. Congdon et al. (1994) reported annual survivorship of adult females ranged from 0.880 to 0.970 for a Michigan population. They also found population stability was most sensitive to changes in adult and juvenile survival and less sensitive to changes in age at sexual maturity, nest survival, or fecundity. Galbraith and Brooks (1987) estimated adult female survivorship at 0.966 for an Ontario population over a 13-year period. This was followed by a two-year period when annual survival of adult females was estimated to be 0.800 and 0.550. The primary cause of the increase in mortality was predation by North American River Otters (*Lontra canadensis*) during hibernation (Brooks et al. 1991).

We determined that legal harvest was the most important cause of mortality at Goose Island and Lawrence Lake during 1997-2000. Legal harvest accounted for 57% of the known mortalities that occurred. During our study, turtle harvesters reported recoveries of radio-marked and banded Snapping Turtles to obtain a reward payment. This provided an opportunity to conduct informal interviews with the turtle harvesters and gain some perspective on trends in turtle harvest and populations on Pool 8. From recoveries of radio-marked and banded Snapping Turtles, we documented that four turtle harvesters were actively trapping Snapping Turtles with hoop nets at Goose Island and one commercial fisherman was operating gill nets at Goose Island. At Lawrence Lake, we determined that two harvesters were actively taking Snapping Turtles. One was operating hoop nets and one was hooking Snapping Turtles from a tributary that entered Lawrence Lake. Interviews with these experienced harvesters indicated that Snapping Turtle populations have declined considerably during the past 20-30 years and larger individuals (>40.0 cm CL) are rare. These harvesters also indicated that current harvest levels are low and most harvesters only keep a few legal-sized Snapping Turtles for personal consumption.

Other sources of mortality that were not documented by our study, but are known to affect northern Snapping Turtle populations include vehicle-caused mortality, predation, and bacterial infection. Vehicle-caused mortality has been well documented (Vogt 1981, Oldfield and Moriarty 1994; Galbraith 2008) and was commonly observed during the nesting season (our study) as females attempted to nest along road shoulders or cross the heavily traveled state highways adjacent to both Goose Island and Lawrence Lake. North American River Otters have been documented to cause significant mortality to local Snapping Turtle

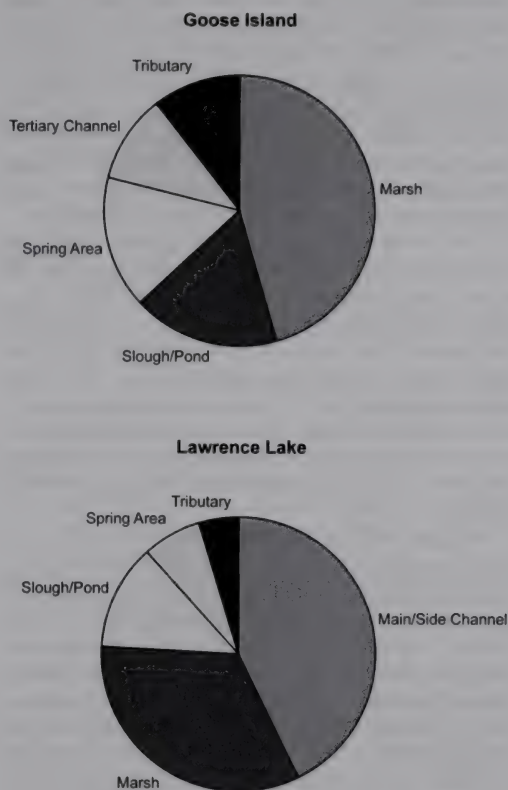


FIGURE 3. Distribution of overwintering radio-marked Snapping Turtles by habitat category at Goose Island and Lawrence Lake study areas on Pool 8, Upper Mississippi River, 1997-2001.

populations at hibernacula during winter. Brooks et al. (1991) recovered 34 adult Snapping Turtle carcasses at their Ontario study area during two winters and determined that most were killed by otters at hibernacula. Park (1971) also reported otters exploiting wintering Snapping Turtles. During one winter, on a three-mile stretch of stream in northern Wisconsin, 27 Snapping Turtle carcasses were observed on the ice following predation by otters. Brooks et al. (1991) noted a few Snapping Turtles died shortly after emerging from hibernation from bacterial infection (septicemia).

Our estimates of home range size were considerably larger than those reported by previous work. Obbard and Brooks (1981) reported home range size averaged 3.44 ha for 10 radio-marked Snapping Turtles at Algonquin Park, Ontario (using the MCP method). Galbraith et al. (1987) also studied home range size at Algonquin Park during a later study period and determined home range size averaged 1.48 ha using the MCP method ( $n = 7$ ). Murphy and Sharber (1973) found home range

sizes averaged 0.65 ha for three radio-marked Snapping Turtles at a Tennessee River study site. By comparison, our MCP home ranges averaged 31.10 ha ( $n = 83$ ) with study sites and sexes combined and the PB mean was 11.13 ha. One plausible explanation for the large home range sizes we observed may be that the vast expanse of aquatic habitat available to Snapping Turtles on the UMR allowed for a greater range of movement with relatively low energetic cost.

The PB method (Hamernick 2001) that we used may be more relevant for estimating home range size for aquatic chelonians because it excludes potentially large areas of terrestrial habitat that would be included in calculating home range size with a method such as the MCP. Similar to the findings of Hamernick (2001), we determined that the PB home range estimates were much more conservative than estimates using the MCP method. Overall, our PB estimates were approximately  $\frac{1}{5}$  the size of the home range estimates using the MCP method.

We observed snapping turtles overwintering singly and communally at Goose Island and Lawrence Lake. Snapping Turtles tended to overwinter communally at backwater sloughs/ponds (primarily in abandoned Beaver bank lodges), spring areas, and tributaries compared to other hibernacula types. An overwintering site of particular significance was the side channel between Lawrence Lake and the main channel of the Mississippi River. Nearly half (40%) of the documented winter sites at Lawrence Lake occurred at this hibernaculum. The side channel was approximately 1600m long and 40m wide with an average depth of 1.0m. Use of this hibernaculum required Snapping Turtles to cross an approximately 70 m strip of wooded upland from Lawrence Lake. The west shoreline was particularly attractive to wintering Snapping Turtles due to heavy woody structure. Seventy-six percent of the winter sites within this side channel were associated with woody structure. Nearly all of the winter sites not associated with woody structure occurred beneath undercut banks. Snapping Turtles used deeper microhabitat (0.6m) within this hibernaculum compared to the overall mean depth (0.4m) that Snapping Turtles selected at other sites.

Data from the Long Term River Monitoring Program (LTRMP) (Shawn Giblin, unpublished data) indicated that dissolved oxygen levels in the side channel were substantially higher (mean = 10.95 mg/L) than sites sampled at Lawrence Lake marsh locations (mean = 4.81 mg/L) during winter (1993-2007). LTRMP sampling also documented that water velocity was higher in the side channel (mean = 0.105 m/s) compared with Lawrence Lake marsh sites (mean = 0.0018m/s) during winter. These data provide a possible explanation why such a high proportion of the Lawrence Lake population moved to this site to hibernate.

## Management Implications

We determined that legal harvest was the most important cause of mortality of adult Snapping Turtles at the Goose Island and Lawrence Lake study areas. While we do not know if recruitment was compensating for this level of mortality, existing literature suggests that Snapping Turtle reproductive success is low and that even low levels of adult mortality may result in population decline (Obbard 1983; Congdon et al. 1987; Congdon et al. 1994; Cunningham and Brooks 1996). From a broader perspective, interviews with turtle trappers and discussions with commercial fishermen indicate that Snapping Turtle populations have declined substantially over the past 20-30 years on Pool 8 of the UMR.

Developing conservative, consistent harvest regulations among the states that border the Upper Mississippi River should be a management priority. The sexual disparity that we observed at both study sites (56% adult males: 40% adult females) warrants a harvest strategy that would at least discourage taking adult females. This could easily be done with a simple drawing in harvest regulation pamphlets that would show cloacal position relative to posterior edge of the carapace to distinguish males from females.

Current turtle regulations in Minnesota and Wisconsin provide protection to Snapping Turtles during the nesting season, but do not adequately protect Snapping Turtles during hibernation when they aggregate (Meeks and Ultsch 1990; Brown and Brooks 1994; Ultsch 2006) and are particularly vulnerable to exploitation. Even with conservative bag limits, these are sites where harvesters can consistently take substantial numbers of adult Snapping Turtles. Using the average dates of hibernacula entry and emergence from this study, protection would effectively be provided if the season were closed from the beginning of October through April. Further, these important overwintering sites need to be considered when habitat projects are being planned on Pool 8 and should be used to model other wintering sites on the UMR.

## Acknowledgments

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ducted preliminary analyses of the spatial data. Jeff Boyne provided weather summary data.

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# Late-Summer Feeding and Migration Behaviour and Numerical Trends of Common Nighthawks, *Chordeiles minor*, near Pinawa, Manitoba, 1976–2009

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Taylor, Peter. 2009. Late-summer feeding and migration behaviour and numerical trends of Common Nighthawks, *Chordeiles minor*, near Pinawa, Manitoba, 1976–2009. *Canadian Field-Naturalist* 123(4): 338–345.

Feeding concentrations of Common Nighthawks, *Chordeiles minor*, during the evening in late summer were observed and counted near the Pinawa, Manitoba, sewage lagoons during 28 of the 34 years from 1976 to 2009. Counts were frequent but non-systematic in 1976–1981, infrequent in 1982–1991, and both frequent and systematic in most years during the period 1992–2009. Results of 226 counts are analysed and interpreted as showing a major decline in the local breeding population during the 1980s but more stable numbers of transient birds, assumed to originate farther north. The timing and other characteristics of feeding and migratory behaviour are discussed. The limitations of interpreting data from a single location are acknowledged and some systematic survey methods are recommended, emphasizing the importance of all-round, long-range visibility to help distinguish between migration and foraging.

**Key Words:** Common Nighthawk, *Chordeiles minor*, threatened species, autumn migration, aerial insectivores, Manitoba.

The Common Nighthawk (*Chordeiles minor*) is one of several aerial insectivores that are declining in numbers, especially in northeastern North America (Sandilands 2007; Conservation Committee of the Society of Canadian Ornithologists-Société des ornithologistes du Canada 2009). It was designated a threatened species in April 2007 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), based on evidence of decline from many sources, including Breeding Bird Survey (BBS) data (Savignac and Leonard 2007). Recent declines in Ontario, based on Breeding Bird Atlas data collected in 1981–1985 and 2001–2005, were most pronounced in the southern Canadian Shield region, but were significant in all regions of the province except the Hudson Bay Lowlands (Sandilands 2007). Data were admittedly sparse in the latter region.

I have previously reported results of surveys of Common Nighthawks during fall migration near the Pinawa sewage lagoons (50°8'N, 95°55'W), about 100 km east-northeast of Winnipeg, Manitoba (Taylor 1996). Those surveys showed a marked drop in numbers from the late 1970s to the early 1990s. This was based on frequent but non-systematic counts of feeding concentrations in 1976–1981 (52 dates, including 19 during the peak period, 11–25 August), infrequent counts in 1982–1991 (14 dates, including 9 during the peak period), and systematic counts in 1992–1995 (56 dates, including 33 during the peak period).

This update incorporates further systematic counts on 104 dates, including 74 during the peak period, in 1996–2009 (except 1998, 1999, 2003, and 2004), plus incidental observations elsewhere in southeastern Manitoba. While year-to-year numerical trends are still of interest, attention was also paid to the timing of feed-

ing concentrations, the distinction between migrating and feeding flocks, and the foraging strategy exhibited by feeding flocks. The limitations of interpreting numbers at a single location are recognized, but some patterns are detected and some general recommendations made for Common Nighthawk surveys.

## Methods

Common Nighthawks were counted around sunset, primarily during the second to fourth weeks of August. The relatively open setting of the sewage lagoons within a mostly forested area gives an uninterrupted view in all directions, except when birds are flying near or below treetop height (Taylor 1996). Birds were counted by 360-degree binocular scans at intervals of about two minutes, starting with either my arrival (if Common Nighthawks were already active) or the appearance of the first birds, and continuing until either the birds dispersed or (more often) poor light prevented accurate counting.

Counting periods varied from about 20 minutes (timed to coincide with the normal feeding peak at dusk) to 2 hours (ending at dusk), usually 30 minutes to 1 hour. It was often possible to extend the counting period by walking around the lagoons until the main feeding flock was silhouetted in the western sky. For counts since 1995, the position of flocks (distance and direction relative to the three lagoons and approximate altitude) was noted, as were the weather conditions, including approximate wind speed and direction.

So long as birds remained above the treetops, exact counts were usually possible for loose flocks of up to 20 Common Nighthawks, and counts were repeatable within about 5% for flocks of 20 to 100 birds. Counting larger numbers became increasingly difficult, with



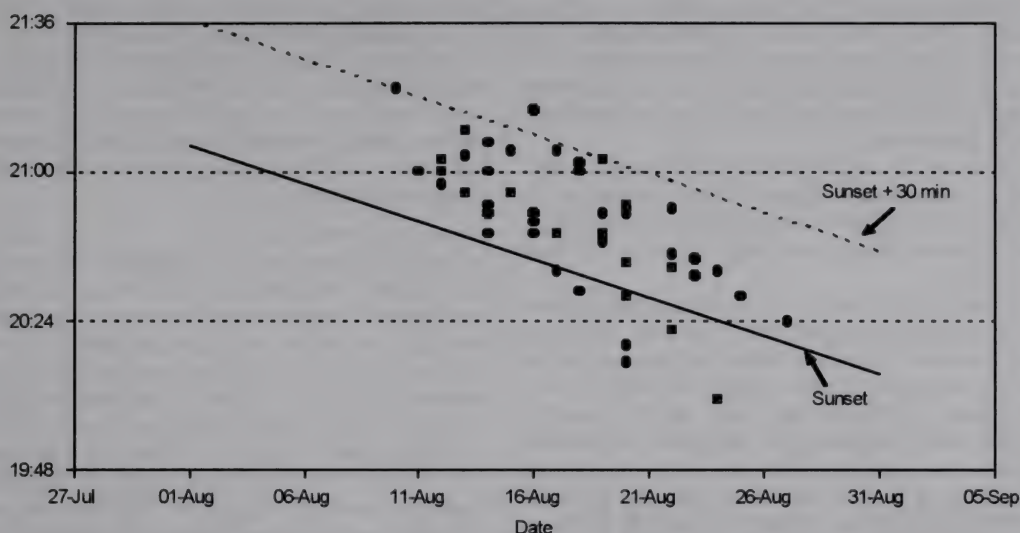


FIGURE 1. Time of peak counts of Common Nighthawks at Pinawa, Manitoba, sewage lagoons, 1994–2008. Data are shown for 47 counts of at least 20 birds, and only for counting periods long enough to show a well-defined peak.

an estimated uncertainty of 10–20% for flocks in the 150–300 range.

## Results and Discussion

Feeding concentrations occurred regularly, with tallies of at least 10 Common Nighthawks in 70 of the 101 counts in 1996–2009 and in 74 of the 105 counts in 1976–1995. Zero totals were recorded just 14 times in the systematic counts (1992–2009) and only 3 times between 11 and 25 August, inclusive; they were not always recorded before 1992.

Common Nighthawks were rarely sufficiently close and well lit to distinguish between adult males, adult females, and immature birds (based on throat and tail patterns, as illustrated by Sibley (2000)), so age and sex data were not available. The characteristic *peent* calls were heard only occasionally from both migrating and feeding flocks.

### Timing of feeding flocks

The first birds often arrived during the 15 minutes before sunset, around 20:30, but sometimes well before 19:00. [All times are reported as Central Daylight Time. Observations refer to official sunset times, which were about 5 minutes later than effective sunset below a distant tree-line.] Numbers usually reached a peak during the half hour after sunset, but sometimes a little before sunset, especially after 15 August (Figure 1). The activity of Common Nighthawks was visible up to 20–40 minutes after sunset, depending on cloud cover and the location of the birds. Post-feeding dispersal was difficult to observe, because of reduced light intensity, but numbers usually declined noticeably before light failed.

Comparable observations were reported by Brigham and Fenton (1991) on foraging flocks of Common Nighthawks from a breeding population along the Okanagan River, British Columbia, in 1985–1987. On average, they observed Common Nighthawks foraging from 28 minutes before sunset to 68 minutes after sunset. Individual birds fitted with radio transmitters averaged 48 minutes of foraging at dusk (Brigham and Fenton 1991). Slightly different times are given by Aldridge and Brigham (1991). That study also included observations of dawn feeding activity, which is of shorter duration.

### Behaviour of feeding flocks

Towards sunset in August, Common Nighthawks typically arrive at the Pinawa sewage lagoons singly or in small groups, sometimes at relatively high altitude (over 100 m), and mostly from the north. It is impossible to say from whence they come, but I have the impression that at least some stage in the area and visit the lagoons from individual roosting sites nearby, whereas others may pause to feed near the lagoons at the end of a migration leg. Groups and scattered individuals gradually form up into one or two loose feeding flocks. Although the flight of individuals seems erratic, these flocks occupy a well-defined volume of airspace.

In moderate winds (10–30 km/h), the flocks commonly form well above treetop height (20–50 m above ground) and up to 500 m downwind of the most south-westerly of the three lagoons, which is a focus of their activity. Within the flock, foraging birds tend to fly slowly into the wind, veering aside from time to time in pursuit of prey, then wheeling back swiftly when

they reach the limit of the foraging space. As darkness falls, the wind speed usually declines, and the Common Nighthawks tend to forage lower and closer to the lagoon, until towards last light they are concentrated directly over the lagoon and often flying within a metre of the water's surface.

In strong winds ( $> 30$  km/h) the Common Nighthawks, if present at all, gather low over the treetops. In light winds ( $< 10$  km/h) they still form feeding flocks, but the location is less predictable with respect to wind direction.

Common Nighthawks thus appear to exploit a plume of flying insects emerging from the lagoon, starting at the downwind end of the plume and finishing at the source and perhaps benefiting from reflected light from the water as ambient light levels fall. As noted by Aldridge and Brigham (1991), Common Nighthawks (unlike bats, *Eptesicus fuscus*) are able to forage only when there is some illumination. Brigham and Fenton (1991) observed that, at both dusk and dawn, Common Nighthawks began foraging bouts above treetop height ( $> 30$  m), then gradually foraged at lower altitudes, eventually flying less than 0.5 m above the surface of the river before departing. Since light intensity increases at dawn and decreases at dusk, this behaviour seems to have more to do with systematic exploitation of an insect swarm than with illumination levels.

At times the Common Nighthawks concentrate elsewhere within sight of the lagoons, presumably wherever insect prey numbers are highest on a given evening. Birds often move back and forth between feeding flocks. During August of 2007, 2008, and 2009, Common Nighthawks paid less attention than usual to the southwestern lagoon, perhaps because major blooms of duckweed (*Lemna* sp.) and algae there had reduced insect productivity. Overall Common Nighthawk numbers were also low in those three years. A change in lagoon management practice during the 1990s, with reduced draw-down of water levels, may also have affected prey productivity in recent years. I have fewer systematic data on other insect-eating birds at the lagoons. Swallow numbers (mostly Barn Swallows, *Hirundo rustica*) held up well from the late 1970s to the mid-1990s (Taylor 1996), but concentrations now seem more sporadic than formerly. Bonaparte's Gull (*Chroicocephalus philadelphia*), Black Tern (*Chlidonias niger*), and Red-necked Phalarope (*Phalaropus lobatus*), all of which feed on insects on and/or above the lagoons, are also less numerous now than in the 1970s and 1980s (Taylor 1983, 1993).

Common Nighthawks feed on small insects that are rarely visible with binoculars, let alone identifiable. The birds appear to ignore concentrations of dragonflies (mostly darners, *Aeshna* spp.) that sometimes hunt near the lagoons in large numbers around sunset, consistent with observations in Minnesota (Eckert and Hendrickson 1991). Numbers of Common Nighthawks did not vary systematically with the subjective

nuisance level of mosquitos. Huge numbers of flies (possibly small chironomids) emerging from one of the lagoons on 16 August 1997 attracted an unusually large feeding flock of about 150 Common Nighthawks. In the Okanagan River study, Common Nighthawks showed a strong preference for caddisflies (Trichoptera) and flying ants (Formicidae), but tended to ignore chironomids (Brigham 1990).

#### *Timing of migrating flocks*

Flocks that were obviously migrating were observed less frequently than foraging flocks; migrating flocks were typically seen or reported to me on no more than three days per season, often over the town of Pinawa or elsewhere in the area. They were most often seen between 18:00 and 19:30, and occasionally earlier in the day. Concentrations of 25 or more birds were noted on dates from 12 August to 1 September, with about 75% of reports between 17 and 26 August, inclusive. Reto Zach counted 152 Common Nighthawks migrating over Pinawa in five minutes on the evening of 17 August 1997. [Observations cited without published references were obtained by personal communication or indirect correspondence.] He also noted a strong movement on 21 August 2001, with some flocks moving steadily, starting around 18:00, and a foraging flock of 65 birds later in the evening.

This situation is comparable to observations at Duluth, Minnesota, where concentrations of Common Nighthawks in August have occasionally exceeded 10 000 birds (Eckert 1986; Eckert and Hendrickson 1991; Nicoletti 1997). Major flights there occurred between 14 and 27 August, inclusive, usually on days with above-normal temperatures and light winds, starting in late afternoon and ending or slowing down about one-half to one hour before sunset (Eckert and Hendrickson 1991). Morning as well as afternoon flights have been observed at Hawk Ridge, near Duluth (Nicoletti 1997).

#### *Behaviour of migrating flocks*

Migrating Common Nighthawks usually fly in a constant direction, without deviating to pursue insects, as noted by Brigham and Fenton (1991) for day-flying individuals in general. Not all flocks of Common Nighthawks, however, fit neatly into a feeding or migrating category. Some flocks pass the Pinawa lagoons around sunset without stopping, whether or not a feeding flock is already present: are they migrating or just heading for a different feeding area? A good example involving large numbers took place on 24 August 2000. Whereas 96 Common Nighthawks were seen between 20:30 and 20:50, the feeding flock never exceeded 18 birds. Another 62 passed high over the lagoons in a south-southeasterly direction without feeding, and another 16 flew steadily eastward, hawking for insects as they went.

Between 18:00 and 19:30 on 24 August 1997, I watched a movement of at least 30 Common Night-



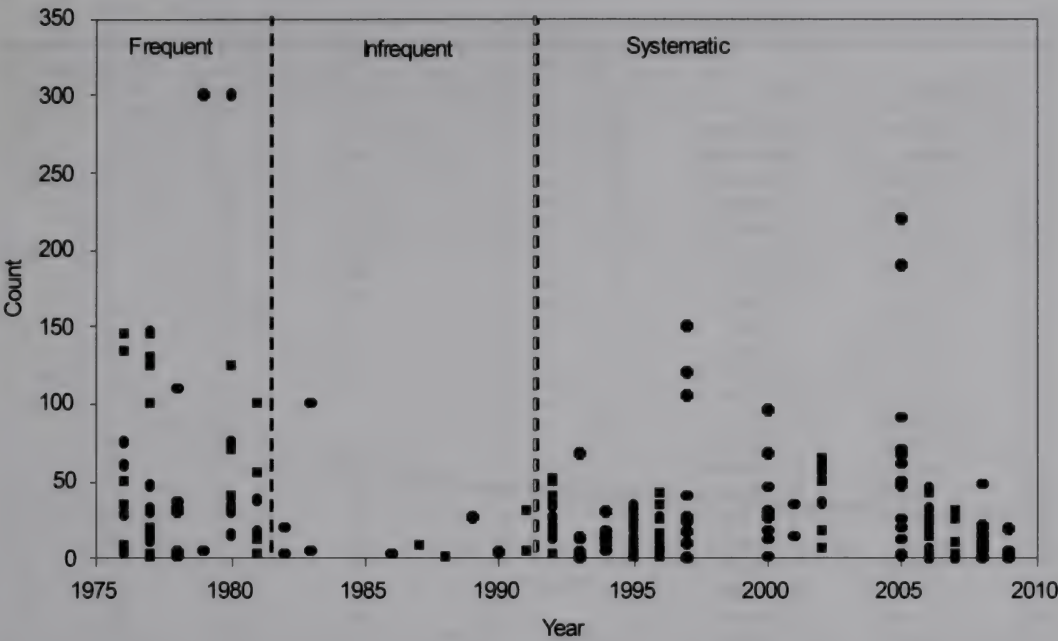


FIGURE 2. Compilation of all counts of Common Nighthawks at Pinawa, Manitoba, sewage lagoons, 1976–2009, sorted by year. Vertical dashed lines separate the three phases of the data collection.

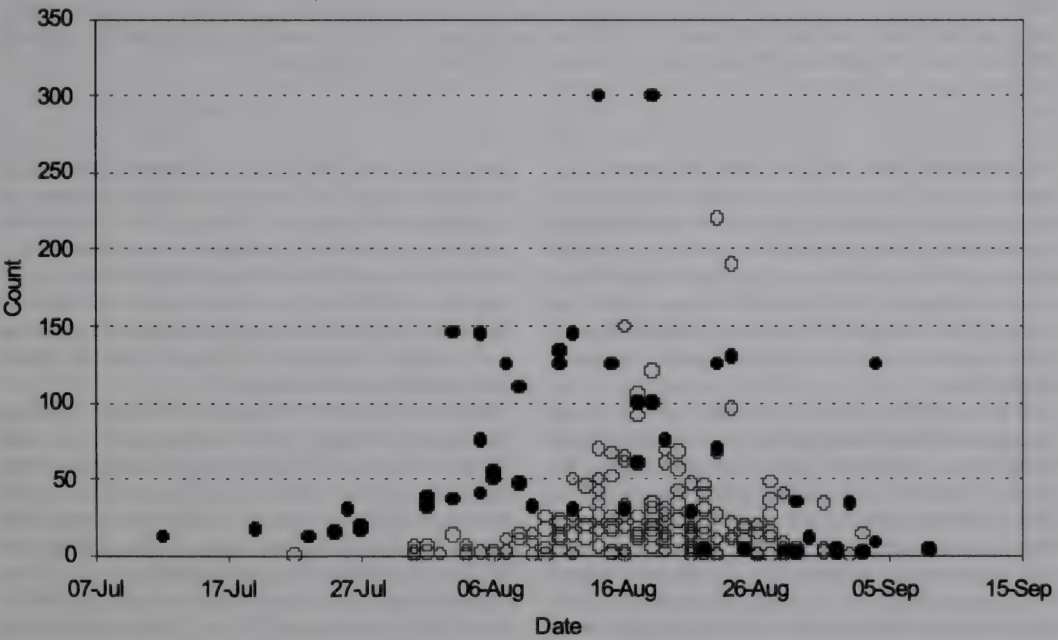


FIGURE 3. Compilation of counts of Common Nighthawks at Pinawa, Manitoba, sewage lagoons, for selected periods, sorted by date. Filled circles, 1976–1981; open circles, 1992–2009.

TABLE 1. Summary of Common Nighthawk counts at Pinawa, Manitoba sewage lagoons, 1976–2009.

Year	Earliest	Latest	Number of counts		Maximum count		August counts only	
			All	11–25 August	Number	Date (August)	Mean	SD
1976	5 August	8 September	10	4	145	12	75	48
1977	12 July	3 September	18	6	146	5	82	56
1978	3 August	1 September	7	3	110	8	36	35
1979	14 August	22 August	2	2	300	(14)	–	–
1980	25 July	4 September	8	3	300	(18)	–	–
1981	23 July	3 September	7	1	100	(18)	–	–
1982	23 August	30 August	2	1	20	(30)	–	–
1983	10 August	22 August	4	3	100	(22)	–	–
1986	12 August	25 August	2	2	3	(12, 25)	–	–
1987	12 August	12 August	1	1	8	(12)	–	–
1988	14 September	14 September	1	0	–	–	–	–
1989	10 August	10 August	1	0	26	(10)	–	–
1990	29 August	29 August	1	0	4	(29)	–	–
1991	21 August	23 August	2	2	31	(21)	–	–
1992	7 August	3 September	11	6	52	15	29	15
1993	10 August	28 August	7	5	68	23	19	23
1994	15 August	24 August	10	10	30	22	13	7
1995	31 July	1 September	28	12	34	20	10	9
1996	9 August	29 August	13	9	42	20	17	12
1997	22 July	25 August	14	10	150	16	46	47
2000	17 August	26 August	8	7	96†	24	37	30
2001	14 August	22 August	2	2	35	(14)	–	–
2002	4 August	27 August	7	5	65	16	42	21
2005	10 August	29 August	13	10	220	23	71	63
2006	31 July	26 August	14	11	45	13	21	14
2007	7 August	28 August	11	6	31	22	7	11
2008	6 August	28 August	13	9	48	27	13	12
2009	1 August	2 September	9	5	19	15, 22	7	7

† Mostly passing birds (see text); next highest, 68 on 20 August 2000.

NOTE: For years with fewer than five August counts, mean and standard deviation (SD) are not given and peak dates are shown in parentheses. The high SD values are of limited use, because they reflect sampling throughout the migration period, including low numbers in the early and late stages, as well as day-to-day fluctuations.

hawks over the town of Lac du Bonnet (about 20 km northwest of Pinawa). They flew erratically, with much circling and backtracking, unlike the direct flight of most migrating birds. Perhaps they were assessing the insect supply for an evening feed after a leg of their migration. Similarly, on or about 20 August 1987, an evening flock of about 60 Common Nighthawks over Pinawa seemed to be in transition between migration and feeding.

At about 19:00 on 27 August 2008, Reto Zach and I observed a loose flock of at least 34 Common Nighthawks flying southward over a large marsh in the Pinawa Channel, about 3 km north of the sewage lagoons. Although the flock was making steady progress, some birds paused to forage briefly above the marsh before continuing on their way. A concentration of 48 Common Nighthawks at the lagoons at 20:20 the same evening (the highest count of the year) may well have included these birds.

On 12 August 2005, Sharon Taylor and I were watching a feeding flock of about 50 Common Nighthawks at the Pinawa lagoons when a brief rain squall passed

through from the west. Most birds continued feeding during the squall. At 21:15, after the squall had passed, a concentrated group of 33 birds quickly disappeared in direct, purposeful flight east-southeast, seeming to take advantage of favourable winds behind the squall line. Other observers have mentioned that flocks of Common Nighthawks sometimes appear just before or after thunderstorms (R. Tuokko, M. Zach, N. Bremner, personal communication).

On 21 August 2005, I watched 32 feeding Common Nighthawks abruptly gather into a tighter group and swiftly fly more than 1 km to the east-southeast. They then paused, broke formation, and gradually straggled back to re-form a feeding flock over the lagoons, the urge to feed apparently overcoming the urge to migrate. Feeding conditions were apparently good that year, because a few nights later I recorded the largest flocks since 1980: an estimated 220 on 23 August 2005 and 190 the following evening. This example, and several other cases of high counts on two or three consecutive evenings, support the idea that migrating flocks sometimes stage in the area for a few days.



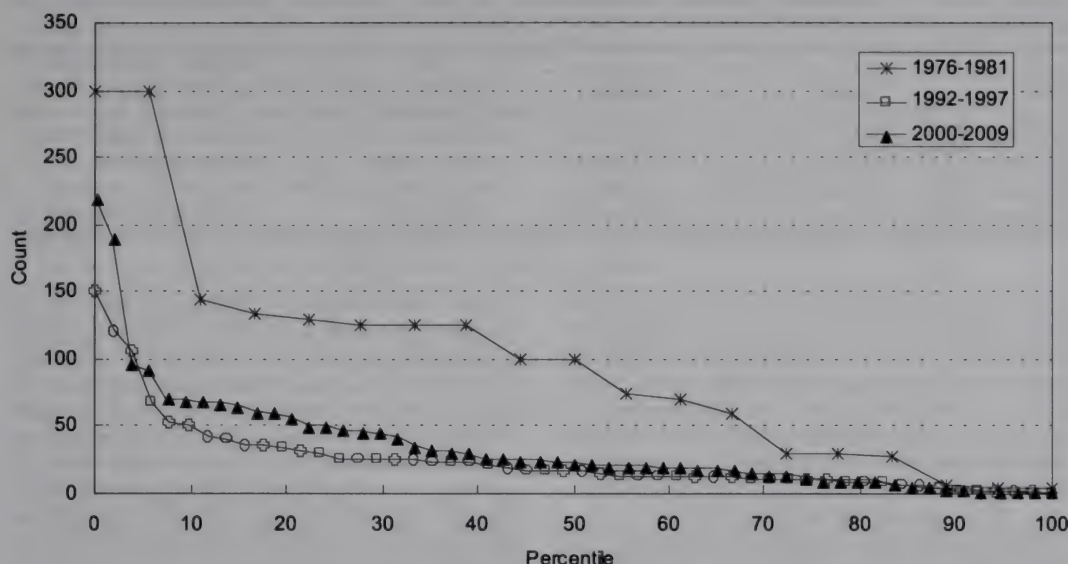


FIGURE 4. Distribution of count values for 11–25 August, expressed as percentiles for the periods 1976–1981 (asterisks), 1992–1997 (open circles), and 2000–2009 (solid triangles). Highest value = 0 percentile, lowest value = 100 percentile, all other values are shown in descending order.

#### *Numerical trends and fluctuations*

Count data are summarized in Table 1. Tallies of Common Nighthawks from all 226 counts over the 34-year period of this study are shown graphically in Figure 2 (sorted by year) and Figure 3 (sorted by date). Figure 3 discriminates between early (1976–1981, filled circles) and more recent counts (1992–2009, open circles), and excludes the sparse data for 1982–1991. Figure 4 compares the distribution of count values for the peak migration period from 11 to 25 August, expressed as percentiles, and pooled for the time intervals 1976–1981, 1992–1997, and 2000–2009.

The numbers of Common Nighthawks show strong day-to-day and year-to-year fluctuations, making analysis difficult; simple trend analyses can be strongly influenced by a single high year, such as 2005 (Figure 2). Similarly, huge fluctuations in numbers have been noted in the large August concentrations near Duluth, Minnesota (Eckert 1986; Eckert and Hendrickson 1991; Nicoletti 1997). The fluctuations are presumably linked to weather patterns prompting the birds to migrate or concentrate, local factors (especially insect availability) prompting them to linger or not, and the condition of the birds (e.g., fat reserves on arrival in the Pinawa area), as well as year-to-year variations in the source population's size and breeding productivity.

For the period 31 July to 11 August, all 1976–1981 counts were considerably higher than all subsequent counts on corresponding dates, whereas counts for the balance of August are less obviously discriminated

(Figure 3). It is plausible that the early August flocks in 1976–1981 were pre-migratory concentrations of local breeding birds and that the counts between mid-August and late August involved a higher proportion of transients, originating farther north. A local contingent was also likely responsible for the significant counts (12 to 30 birds) recorded between mid-July and late July in 1977, 1980, and 1981 (Figure 3). Unfortunately, there are few July data for later years (Table 1). Common Nighthawks apparently disappeared as breeding birds in Pinawa in the early 1980s, although some doubtless continue to breed elsewhere in the region, e.g., in Whiteshell Provincial Park and Nopiming Provincial Park (Taylor 1996). In the Okanagan study, Brigham and Fenton (1991) observed regular feeding flocks of 200–300 Common Nighthawks, presumably local breeders, from early June to mid-July, with numbers declining to 50 or fewer by mid-August. This is consistent with some post-breeding movements occurring before the main migration peak.

Fluctuations in numbers can be smoothed by pooling data for the three periods: 1976–1981, 1992–1997, and 2000–2009. This was done to prepare Figure 4, which is limited to counts during the nominal peak migration period, 11–25 August. [Some of these data were previously published (Taylor 1996).] This period was identified in the earlier study, and it was used to focus systematic survey effort (Taylor 1996). In retrospect, it may be a few days too early and the 15-day window may perhaps be too restrictive; nevertheless, in most years it appears to capture the main

TABLE 2. Reports of Common Nighthawk flocks exceeding 100 birds in Manitoba (except Pinawa townsite and sewage lagoons) since 1995.

Date	Number	Observer	Location	Direction and distance from Winnipeg
21 August 1998	200+	A. Walley	Holland	130 km west-southwest
23 August 2000	100+	R. Tuokko	Pinawa Lake	130 km northeast
24 August 2000	224 (several flocks)	D. Fast	Manigotagan to Stead	140 to 80 km northeast
21 August 2001	200+	P. Goossen	Falcon Lake	100 km east-southeast

migration peak. When the distribution of all count data is depicted, there is still a clear discrimination between high counts in 1976–1981 and markedly lower counts in subsequent years (Figure 4). This is illustrated dramatically if we consider the number of tallies of 100 or more birds—50% of the counts and 5 out of 6 years in 1976–1981 had 100 or more birds, but only 5% of the counts and 2 out of 14 years in 1992–2009 achieved that number.

The main difference between the 1992–1997 and 2000–2009 count distributions lies between the 5th and 35th percentiles (Figure 4), reflecting some high counts in three of the eight years sampled: 2000, 2002, and 2005 (Figure 2). The patterns shown in Figure 4 are again consistent with a decline in Common Nighthawks during the 1980s (possibly involving mainly local birds) but a more stable source population of transient birds, whose origin is unknown but could be far north of the Pinawa area (or northwest, given the often easterly drift of their movements). In turn, this is consistent with the suggestion of pronounced declines in the southern Canadian Shield region of Ontario but more stable numbers in the Hudson Bay Lowlands region (Sandilands 2007).

#### *Observations elsewhere in Manitoba*

In October 2000, the late Norm Cleveland sent me a list of 36 counts of Common Nighthawks made during the evening in August from his home in the Niakwa Park area of Winnipeg, about 1.5 km east of the Red River, in 28 years between 1968 and 2000, inclusive. On 30 August 1973, he noted “large numbers, afternoon and evening”. Numbers were particularly high in the early 1980s, with five counts of more than 100 birds in 1980–1983 and a peak of 325 on 20 August 1981. His only other three-figure total was an estimate of 100 on 28 August 1992; only single-digit numbers were observed in subsequent years. The 17 highest counts (of at least 20 birds) occurred between 14 and 31 August, inclusive, with only two of these 17 counts being later than 1984. The relative contributions of urban breeders and transients to these former concentrations is unknown, but the peak dates suggest mainly transients. Other Winnipeg birders concur in the near-disappearance of late-summer concentrations of Common Nighthawks from the city’s skies, although Gordon Grief reported a count of 255 migrants as recently as 25 August 1991.

Several anecdotal reports of large concentrations of Common Nighthawks elsewhere in Manitoba, mostly in August, up to 1995, were summarized previously (Taylor 1996). Of particular interest, two pairs of counts indicate widespread one-day movements: 1300 at Delta (P. Grief) and 500+ between Beausejour and Pinawa (R.F. Koes) on 23 August 1993; 625 at Stonewall (K. Gardner) and 600 at Gimli (J. Weshnowski) on 18 August 1995. Concentrations continue to be reported from time to time. Reports of more than 100 birds are summarized in Table 2.

#### **Conclusions and Recommendations**

When surveying Common Nighthawks during fall migration, it is important to have good all-round, long-distance visibility and to track the movements of flocks in order to distinguish between feeding and actively migrating birds. Migration in southern Manitoba is often concentrated into a few days within a two-week period in mid-August to late August, whereas feeding concentrations at favoured locations, such as the Pinawa sewage lagoons, occur almost daily during that period. It is likely that many of these feeding birds stage in the area for two or more days.

Sharp peaks and both day-to-day and year-to-year fluctuations make numerical trends difficult to discern. These complicating factors are true of any bird migration data, e.g., from hawk watches, sea watches, and migrant banding stations. Daily counts of Common Nighthawks at multiple locations would perhaps improve the monitoring of population trends, but would require a large commitment of effort. Unfortunately, such counts are not amenable to “piggybacking” on other surveys, except perhaps some hawk watches. It is also unfortunate that the boreal portion of the breeding range is poorly represented in the Breeding Bird Survey (because of inaccessibility) and that the detection efficiency of the BBS for Common Nighthawks is low because of their crepuscular habits.

The decline in August concentrations of the Common Nighthawk near Pinawa from the early 1980s to the mid-1990s (Taylor 1996) did not continue during the following decade. This is consistent with the near-disappearance of local breeding birds by 1990, but a more stable source population of transient birds. Detailed analysis of the dates of concentrations also supports this conclusion.



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# Historical Range, Current Distribution, and Conservation Status of the Swift Fox, *Vulpes velox*, in North America

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The Swift Fox (*Vulpes velox*) was once common in the shortgrass and mixed-grass prairies of the Great Plains of North America. The species' abundance declined and its distribution retracted following European settlement of the plains. By the late 1800s, the species had been largely extirpated from the northern portion of its historical range, and its populations were acutely depleted elsewhere. Swift Fox populations have naturally recovered somewhat since the 1950s, but overall abundance and distribution remain below historical levels. In a 1995 assessment of the species' status under the US Endangered Species Act, the US Fish and Wildlife Service concluded that a designation of threatened or endangered was warranted, but the species was "precluded from listing by higher listing priorities." A major revelation of the 1995 assessment was the recognition that information useful for determining population status was limited. Fundamental information was missing, including an accurate estimate of the species' distribution before European settlement and an estimate of the species' current distribution and trends. The objectives of this paper are to fill those gaps in knowledge. Historical records were compiled and, in combination with knowledge of the habitat requirements of the species, the historical range of the Swift Fox is estimated to be approximately 1.5 million km<sup>2</sup>. Using data collected between 2001 and 2006, the species' current distribution is estimated to be about 44% of its historical range in the United States and 3% in Canada. Under current land use, approximately 39% of the species' historical range contains grassland habitats with very good potential for Swift Fox occupation and another 10% supports grasslands with characteristics that are less preferred (e.g., a sparse shrub component or taller stature) but still suitable. Additionally, land use on at least 25% of the historical range supports dryland farming, which can be suitable for Swift Fox occupation. In the United States, approximately 52% of highest quality habitats currently available are occupied by Swift Foxes.

**Key Words:** Swift Fox, *Vulpes velox*, historical and current distribution, status, Great Plains.

The adaptations of canid species to environmental constraints and their generalist attributes allow canids to occupy a variety of habitats; thus, many canid species have relatively broad distributions that span a variety of environmental conditions. Historically in North America, the Red Fox (*Vulpes vulpes*) and Gray Wolf (*Canis lupus*) were found throughout most of the continent (see Hall 1981). Other canid species, such as the Arctic Fox (*Alopex lagopus*), Kit Fox (*Vulpes macrotis*), and Swift Fox (*Vulpes velox*), were largely confined to specific biomes (i.e., arctic tundra, western arid and semiarid deserts, and temperate grasslands, respectively). The distributions of most North American canids have been dynamic, with expansions and contractions occurring through time in response to a variety of factors (Johnson and Sargeant 1977; Johnson et al. 1996; Laliberte and Ripple 2004). Climatic influences (e.g., Hersteinsson and Macdonald 1992), competition from larger canid species (e.g., Johnson and Sargeant 1977; Dekker 1989; Hersteinsson and Macdonald 1992), and human persecution (e.g., Young and Goldman 1944; Johnson and Sargeant 1977; Thiel and Ream 1995) are among acknowledged causes of wide-scale changes to or limits in distributions among canid species.

Based on Swift Fox behaviors, habitat use, and historical records, many biologists believe that the pre-

settlement range of the Swift Fox was influenced by, and largely restricted to, the expanse of shortgrass and mixed-grass prairies of North America (see Kahn et al. 1997\*). Reasoning behind this belief is that Swift Foxes prefer habitats with short vegetation structure, which provides good mobility and visibility for easier detection and evasion of potential predators (Kilgore 1969; Hines 1980; Carbyn et al. 1994). Results from recent studies strongly demonstrated this implicit preference for landscapes that are open and level or gently rolling to landscapes that are rugged or with tall grasses or shrubs (Kitchen et al. 1999; Olson and Lindzey 2002; Kamler et al. 2003; Sovada et al. 2003).

Monitoring species' distributions and populations over time is an important tool for the management of wildlife species, especially for species of special conservation concern, such as the Swift Fox (Ruggiero et al. 1994). The ability to detect changes in a species' distribution or relative abundance allows a managing agency to respond to potential threats to the health of populations. Estimates of density are preferred to monitoring distributions, but population measures beyond distribution typically are more difficult to obtain. Sampling procedures sufficient to attain accurate density estimates, however, can be costly, and such estimates may not be needed for management purposes (Caughley 1977). The proportion of historical range



that is occupied by a species often is one factor considered when the status is being assessed under the US Endangered Species Act (Scott et al. 2006).

#### Historical Range

There are challenges in delineating the historical geographic range for the Swift Fox because verified records are sparse and many observational accounts are vague (Kahn et al. 1997\*), but mainly because the extent of habitat that was suitable for occupation by Swift Foxes was dynamic over time. A fossil record (Holocene period) from eastern Missouri (Parmalee et al. 1969), which is considerably east of the species' range at the time of settlement, exemplifies the spatial and temporal changes in the species' distribution and extent of suitable habitats. In more recent history, the boundaries of the short-stature grasslands preferred by Swift Foxes have been in flux due to climatic, edaphic, and biotic influences (e.g., grazing by American Bison [*Bison bison*]; Küchler 1972; Risser et al. 1981; Küchler 1985; Weaver et al. 1996). The eastern boundary of short-stature grasslands is particularly ambiguous because of the adaptive response of native grasses to spatial and temporal variation in precipitation. Fluctuations in precipitation and concomitant unpredictability of resources are characteristics of mixed-grass prairie regions. In mixed-grass prairies, when rain is abundant, tall-structured grasses dominate; when dry conditions persist, short grasses dominate (Küchler 1972). Given the Swift Fox's preference for short-stature grasslands, it is ecologically reasonable to assume that its distribution repositioned with climatic variation over time.

Another factor that confounds efforts to define the boundaries of the historical range of the Swift Fox is misidentification of specimens or records, which, in some instances, overextended the Swift Fox historical distribution. For example, a Kit Fox (*Vulpes macrotis*) that was collected in northwestern New Mexico (Bernalillo County), well outside the range of the Swift Fox, was mistakenly recorded as a Swift Fox in museum records (Museum of Southwestern Biology, University of New Mexico record #101289). In some cases, the collection location for a museum specimen was erroneously recorded as the fur-trading post rather than the actual point of collection. More problematically, there was often a lack of data points necessary to improve precision when the extent of the species' range was being plotted.

From the mid-1800s to the early 1900s, the Swift Fox suffered a dramatic contraction in distribution and a population decline directly or indirectly linked to human activities (Allardyce and Sovada 2003). Intense trapping efforts directly contributed to these declines; records from the Hudson's Bay Company showed that 117 025 Swift Fox pelts were sold in London, England, between 1853 and 1877 (Rand 1948). One of the most important causes of population decline was arguably the inadvertent poisoning of Swift Foxes with strychnine-laced baits, which were widely used

to control wolves. Swift Foxes readily consumed poisoned baits and reportedly died by the thousands (Bailey 1926; Young and Goldman 1944; Allardyce and Sovada 2003). By 1885, the wolf population had been largely decimated in the plains (Hampton 1997), and the Swift Fox population suffered a similar demise. Poisoning subsided by the late-1800s, but trapping and hunting of wolves and Coyotes (*Canis latrans*) continued, with bounties being used as an incentive. By the early 1900s, the Swift Fox was considered extirpated from Montana, North Dakota, Nebraska, Kansas, and Oklahoma and acutely depleted elsewhere in the United States (i.e., South Dakota, Wyoming, Colorado, New Mexico, Texas); it was also extirpated from Canada (Baker 1889; Fowler 1937; Allardyce and Sovada 2003).

Simultaneous with the campaigns to eradicate wolves were changes in the landscape that curtailed any potential for recovery of Swift Fox populations once poisoning and other pressures subsided. Large expanses of mixed-grass prairies were converted to cropland (Samson and Knopf 1994; Samson et al. 1998). The drier shortgrass prairie was less suitable for grain farming but was amply suited to livestock production; native grazers, such as the American Bison and prairie dogs (*Cynomys* spp.), were largely replaced by domestic cattle, which have different grazing behaviors (Schwartz and Ellis 1981). It is not clear how these changes affected Swift Foxes with regard to habitat requirements, but it is likely that these changes indirectly influenced Swift Fox populations by reducing prey populations. Additionally, northern populations of Swift Fox might have relied heavily on carrion, such as American Bison killed by Gray Wolves or dying of natural causes, to survive severe winter conditions (Carbyn 1986; Klausz et al. 1996). This substantial food source was no longer available once wolves and bison were eradicated or had retreated from the region. Other scavengers, such as the Turkey Vulture (*Cathartes aura*), Black-billed Magpie (*Pica hudsonia*), and Common Raven (*Corvus corax*), experienced similar range contractions and population declines in the prairies, ostensibly with the disappearance of the American Bison (Houston 1977; Tallman et al. 2002).

Beginning in the late 1950s, Swift Fox populations showed signs of natural recovery in the United States as observations were being reported with increasing frequency in core areas of the species' historical range (e.g., Martin and Sternberg 1955; Glass 1956; Anderson and Nelson 1958; Andersen and Fleharty 1964; Long 1965). This trend has continued in some parts of the species' range (Sovada and Scheick 1999\*). Today, Swift Foxes are thriving in the plains of Colorado, Kansas, Oklahoma, New Mexico, and Wyoming. Small native populations of Swift Foxes occur in Nebraska, South Dakota, and Texas but are isolated from core populations, as are reintroduced (but expanding) populations in Canada, Montana, and South

TABLE 1. Source (museum or published record) of historical Swift Fox locations near the margins of the species' range. Individual locations are mapped on Figure 1 and identified by the Map ID in this table.

State/ Province County	Map ID	Year and nearest named location	Museum catalog number or published source
<b>Montana</b>			
Glacier	6	1806, Two Medicine Creek 1901–1906, near Blackfoot and Kipp (42 specimens collected)	Lewis and Clark <i>in</i> Burroughs (1961) National Museum of Natural History 108260, 108318-9, 116560-1, 130059, 133091-4, 135129, 136566, 139185-7, 145874-7, 146226-8, 146311- 25, 146372-3, 146563-4, 147597, 147767 Bailey and Bailey (1918)
		ca. 1918, no location	Lewis and Clark <i>in</i> Burroughs (1961)
Cascade	8	1805, Great Falls	National Museum of Natural History 67599
Pondera	7	1894, no location	McChesney (1879*) <i>in</i> Knowles et al. (2003)
Big Horn	9	1879, Fort Custer	
<b>Wyoming</b>			
Carbon	10	1898, Aurora Lake 1856, Bridger Pass	American Museum of Natural History 14499-14503 National Museum of Natural History 1871
Laramie	11	1870, Cheyenne	Yale Peabody Museum YPM37
<b>Colorado</b>			
Boulder	13	1903, Boulder	Cary (1911)
Adams	14	1914, Brighton 1916, Simpson	Denver Museum of Nature and Science Denver Museum of Nature and Science (9 specimens)
Denver	15	1878, Denver	American Museum of Natural History 24419
El Paso	16	1878, Colorado Springs 1933, no location 1957, Security	American Museum of Natural History 24420 University of Colorado 10797 University of Colorado 7187
Jackson	a	1893, location not described	Cary (1911), but Armstrong (1972) was skeptical of record
Pueblo	17	No date, location not described	National Museum of Natural History <i>in</i> Armstrong (1972)
Otero	18	1848, Bent's Fort	Emory (1848*)
Weld	12	1910, Cornish	University of Colorado 230-231
<b>New Mexico</b>			
Union	19	1893, Clayton	Seton (1929)
San Miguel	20	1879, Cobra Springs	National Museum of Natural History 16240
<b>Texas</b>			
Martin	21	1902, Stanton	National Museum of Natural History 126222
Midland	22	1905, no location	Bailey (1905)
<b>North Dakota</b>			
Cavalier	23	ca. 1801, no location	Swanson et al. (1945)
<b>South Dakota</b>			
Hughes	24	1917, no location	National Museum of Natural History 300300
<b>Nebraska</b>			
Antelope	25	1900, north part of county	Cary manuscript (ca. 1905) <i>in</i> Jones (1964)
Kearney	27	1853, Fort Kearney	National Museum of Natural History A1343-A1348
Saline	b	ca. 1900, no location	Cary manuscript (ca. 1905) <i>in</i> Jones (1964), but record was questioned by R. Timm, Curator of Mammals, University of Kansas (personal communication)
Madison	26	1900, no location	Cary manuscript (ca. 1905) <i>in</i> Jones (1964)
<b>Kansas</b>			
Trego	28	1880s, no location	National Museum of Natural History A 21663
Ness	30	no date, "Schoharie" historical town	American Museum of Natural History 16609, New York Zoological Society
Kingman	31	1860s, C(S)hikaskia	National Museum of Natural History 8538
Rush	29	1861, Walnut Creek	Grinnell (1914)
<b>Canada</b>			
Alberta	1	1897, Buffalo Lake	Museum of Comparative Zoology B7719
	2	Pre-1928, High River	Anthony (1928)
	3	1904, Lethbridge	Royal Ontario Museum 21578
	4	1894, Medicine Hat	National Museum of Natural History 69460-69463
	5	ca. 1900, Cardston	Soper (1964)



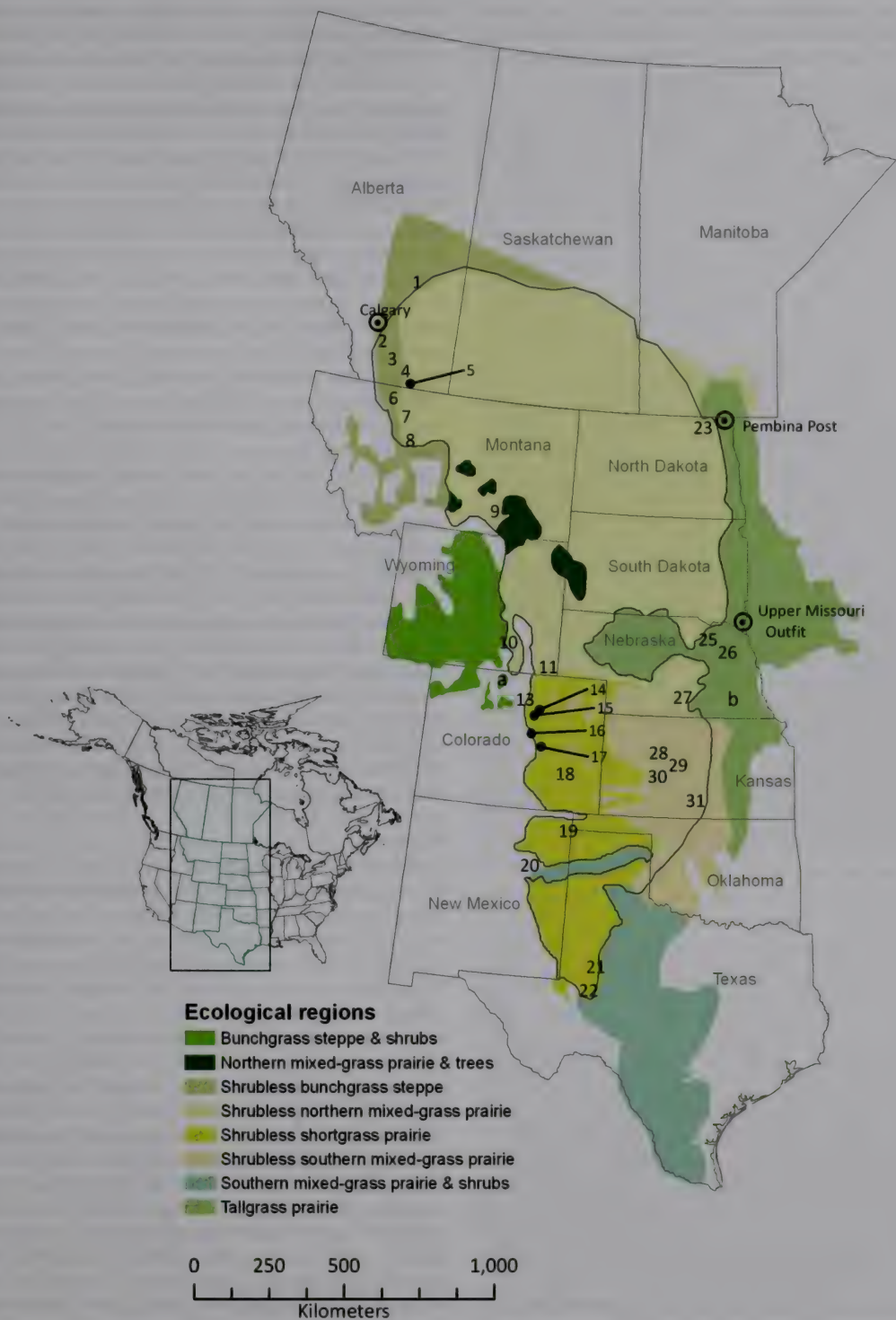


FIGURE 1. Ecological regions modified from Risser et al. (1981) and boundary (black line) of the estimated historical range of the Swift Fox in the United States and Canada. Numbers and letters indicate locations of Swift Foxes from historical records listed in Table 1.

Dakota (Allardyce and Sovada 2003). The species remains absent from large parts of its historical range (e.g., North Dakota, parts of Canada, and Texas).

#### *Administrative status and conservation*

In Canada, the first formal recognition of the tenuous status of the Swift Fox occurred in 1978, when the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Swift Fox as extirpated (Saskatchewan Department of Tourism and Renewable Resources 1978\*; Brechtel et al. 1996\*). The species' status in Canada was changed to endangered in 1999 subsequent to reintroduction of Swift Foxes at sites in southern Alberta and southern Saskatchewan (Carbyn 1998\*; Moehrenschrager and Sovada 2004). The Swift Fox Recovery Team was established in Canada in 1989 to guide conservation and recovery efforts for the species (Carbyn 1995).

In the United States, the US Fish and Wildlife Service (USFWS) received a petition in 1992 to list the Swift Fox under the US Endangered Species Act. Following this review, the USFWS concluded that listing of the Swift Fox was "warranted but precluded by higher listing priorities" (USFWS 1995). The published finding stated that the Swift Fox had been extirpated from approximately 80% of its historical range and that remaining populations existed in scattered, isolated pockets of remnant shortgrass and mixed-grass prairie habitats. The USFWS estimated that approximately 45% of the Swift Fox's habitat throughout its historical range within the United States had been lost as a result of prairie conversion, based on US Department of Agriculture data from 1989 (USFWS 1995). Remaining native prairies often were fragmented into smaller and more isolated grasslands, reducing available habitat and prey. In response to the petition for listing, wildlife management agencies from the 10 affected states (i.e., those located within the historical range of the Swift Fox)—and, later, interested cooperators (federal agencies, conservation organizations, representatives from Canada, the American Zoological Association, tribal entities)—formed the Swift Fox Conservation Team (Dowd Stukel et al. 2003). Because large areas of suitable habitats were not occupied by the species, experts believed that the Swift Fox was a species with potential to expand its distribution. Recent successes of reintroductions (see Discussion section below) substantiated this assumption.

The Swift Fox Conservation Team developed the *Conservation Assessment and Conservation Strategy* (Kahn et al. 1997\*), to be implemented in lieu of applying the Endangered Species Act as a means of conserving the species (Dowd Stukel et al. 2003). The document outlines short- and long-range goals, objectives, and strategies for management of the Swift Fox throughout its range in the US. The Strategy is considered a working document that is modified periodically based on the accomplishments of the Swift Fox Conservation Team, new information, and data

needs. That is, objectives and strategies are prioritized and accomplishment dates are set, based, in part, on the USFWS's recommendations and suggestions to the Team; accomplishments are reviewed and reported on an annual basis. One recommendation presented in the Strategy was that Swift Fox distribution be re-evaluated every five years. Over time, population declines or increases and contractions or expansion of areas occupied by Swift Foxes can be detected; marked declines or range contractions should trigger action by the Team. The Strategy also identifies criteria for evaluating the success of the conservation strategy, including having the United States population of Swift Foxes occupy a minimum of 50% of the suitable habitat that is available (Conservation Assessment and Conservation Strategy, page vii). Therefore, to assess species status, the USFWS requires a sensible estimate of the historical range as well as the current distribution.

In this paper, we present an estimate of the historical range of the Swift Fox based on an integration of available records (e.g., museum records, accounts by early explorers) with physiographic habitat types (Risser et al. 1981) that have been identified by experts as suitable for occupation by Swift Foxes. Also presented is an estimate of the current distribution of the Swift Fox, based on presence/absence survey data collected between 2001 and 2006. Finally, the area of potential occupation (i.e., predicted distribution) within the historical range is estimated, based on current apportionment of suitable habitats. The range boundaries should be considered tentative and dynamic rather than distinct, and some areas within this geographic range are not occupied or may be unsuitable for occupation.

#### **Methods**

The historical range of the Swift Fox was estimated by compiling published information, museum records, university records, state agency records, fur-trade records, and accounts of early naturalists and explorers. Available records were limited and fragmentary and, by themselves, were insufficient to delineate the entire historical range of the Swift Fox. Gaps were reconciled with knowledge of the historical extent of suitable habitat once available for Swift Fox occupation. This was appropriate, because there is compelling evidence (Kilgore 1969; Hines 1980; Kamler et al. 2003; Sovada et al. 2003) and agreement among biologists knowledgeable about Swift Foxes (Swift Fox Conservation Team members; Kahn et al. 1997\*) that short-stature grasslands are preferred to taller vegetation (Harrison and Whitaker-Hoagland 2003; Moehrenschrager and Sovada 2004). Thus, shortgrass and mixed-grass prairies (Risser et al. 1981; Figure 1, Table 1) were considered the starting base map for the species' historical range. If a record of a Swift Fox location was outside the shortgrass or mixed-grass prairies, or if locations seemed spurious, the validity of those records was closely examined. Conversely, if



there were historical records that conspicuously omitted mention of Swift Foxes among detailed and complete mammal accounts, this too was considered when the historical range was being delineated. Once the outer boundary of the historical range had been defined, the area of the range was calculated. Large forested, shrub-dominated, or montane areas within the short-grass and mixed-grass prairies were not included in the range area estimate; however, many smaller areas of unsuitable habitats (e.g., see Hoffmann and Jones 1970) remained in the calculation of areas. Ultimately, the historical range is a liberal estimate of the extent of plains once occupied by Swift Foxes.

The current distribution of the Swift Fox in the United States was estimated with data provided by members of the Swift Fox Conservation Team and cooperators from each of the 10 states located within the historical range of the Swift Fox. Data were compiled from a variety of survey methods (e.g., track surveys, night-lighting, trapping surveys; see the 2001–2006 annual reports of the Swift Fox Conservation Team for details of methods used by state agencies, found at <http://wildlife.state.co.us/WildlifeSpecies/GrasslandSpecies/SwiftFoxConservationTeam.htm>) and other observations (e.g., fur-harvest records, verified sightings, research studies, reintroductions, etc.) of Swift Foxes during 2001–2006. Most states do not conduct annual surveys (e.g., Kansas completes the survey over a three-year period and the survey cycles every five years); therefore, the five-year period of data collection is inclusive among the state agencies conducting the surveys. In the United States, the smallest sample unit that could be consistently applied across the range of the Swift Fox was at the county level. The metric used was occurrence (i.e., presence or absence). For Canada, the distribution of Swift Foxes was based on published surveys (Moehrensclager and Moehrensclager 2006\*). The sample units in Canada were blocks of 93 km<sup>2</sup>, but not all blocks in the region of study were surveyed. An unsurveyed block was considered occupied by Swift Foxes if the unsurveyed block abutted at least two blocks that were occupied. Historical and current distribution boundaries were reviewed for accuracy by a state agency representative of the Swift Fox Conservation Team. The proportion of the historical range still occupied by Swift Foxes, based on the survey results, was calculated.

Several caveats should be considered in interpreting the map depicted herein of the current distribution of the Swift Fox. First, surveys used to generate this map were not all-inclusive of the Swift Fox historical range, and areas that were surveyed were not searched with equal intensity among states and provinces. Management agencies made knowledge-based decisions on the extent of the surveys, limiting their efforts to appropriate areas or habitats within the constraints of resources available for surveys. A county with a single Swift Fox observation was weighted equally to a county with

multiple and widespread observations; thus, inference to numbers of Swift Foxes would be erroneous. Differences among survey methodologies and temporal variation across the range were not measured.

To predict areas with the potential for reoccupation by the Swift Fox under current landscape conditions, land-cover data from GAP analyses (US Geological Survey National GAP Analysis Program, <http://gap.analysis.nbi.gov/portal/server.pt>) and the National Land and Water Information Service (Government of Canada 2008\*) were used. Because of discrepancies among individual states and Canada in vegetative variables used to define land-cover categories, suitability of habitats was considered state by state and for Canada based on the expert opinion of members of the Swift Fox Conservation Team and knowledgeable biologists. Predicted suitability of habitats was categorically ranked as high, medium, or low quality (see Appendix). The high-quality habitats included low to medium structured grassland without a shrub component. Medium-quality habitats included grasslands with a minor shrub component and croplands that could be identified as dominated by dryland cropping methods (crop/fallow rotation). Low-quality habitats included areas dominated by cropland (not identified as dryland) with a mix of grassland in the landscape. In Kansas, Conservation Reserve Program (CRP) fields were delineated in the GAP analysis. Unlike other states in the historical range of the Swift Fox, CRP fields in Kansas are often planted to tallgrass species that are seldom used by Swift Foxes (Sovada et al. 2003), therefore, CRP fields in Kansas were considered low-quality habitat. Land cover was bounded by the species' historical range, and then suitable habitats and habitat features were identified and the area calculated by habitat quality categories.

## Results

### *Historical Records*

Information on Swift Fox distribution from literature, historical records, and national, regional, and university museums in the United States and Canada was sparse. Historical locations of Swift Fox observations were patchy and often unverifiable. Figure 1 shows historical locations of Swift Foxes nearest to the estimated boundaries of the species' distribution, based on published accounts and museum records. A more extensive list (i.e., core and marginal records) of historical records is included in Sovada and Scheick (1999\*). Allardyce and Sovada (2003) reviewed historical literature and records of Swift Foxes in the United States; the following updates that review and include historical accounts from Canada, with a focus on marginal records.

**North Dakota** – The first published record of the Swift Fox was in Alexander Henry's fur shipment records from the Pembina Post of the Northwest Company's Red River District (see Reid and Gannon 1928). The main post was located at the junction of

the Pembina and Red rivers in what is now north-eastern North Dakota, with branch posts to the west in the "Hair Hills" (Pembina Hills) and the mouth of the Red River in Canada. Henry wrote that 117 "kit" foxes were taken between 1800 and 1806, and 120 foxes were received from the Hudson's Bay Company at Pembina in 1805-1806 (note that some early accounts referred to the Swift Fox as Kit Fox). Henry's journals do not identify the specific trapping locations of individual Swift Foxes but rather likely indicate the nearest location where fox pelts were traded. The small number taken in the seven years of records suggests Swift Foxes were not common in the vicinity of northeastern North Dakota during the operation of the Pembina Post. This post was likely near the north-easternmost boundary of the Swift Fox's historical range. Similarly, Reid and Gannon (1928: 188) suggested that Swift Foxes likely were not common in northeastern North Dakota and indicated that "...being a plains animal it is quite probable they were more common farther west." However, Bailey (1926) quoted Charles Cavileer from "A Story of '53" describing the fur trade in Walhalla, as obtaining 400-600 "kit foxes" each year from the Pembina Hills region during a period before the American Bison disappeared.

**South Dakota** – The entire state of South Dakota was generally considered to be within the historical range of the Swift Fox in most published descriptions (Over and Churchill 1941; Hall and Kelson 1959; Egoscue 1979; Hall 1981). However, E. Birney (Bell Museum of Natural History, University of Minnesota, personal communication) and J. K. Jones (Texas Tech University, Lubbock) found no record of Swift Foxes in the easternmost counties (tallgrass prairie) of South Dakota when they were conducting research for their book, *Handbook of Mammals of the North-Central States* (Jones and Birney 1988). Swift Fox remains were found at archeological sites along the Missouri River in four counties, including Walworth (Mobridge site ca. 1650-1700 and Walth Bay site ca. 1550-1600), Buffalo (Medicine Crow site ca. 1700-1750), Sully (Sully site ca. occupied within last 500 years), and Hughes (Pierre Indian Learning Center site ca. 1620-1750) counties (K. Lippincott, South Dakota Archeological Consultant, personal communication). Many Swift Fox pelts were traded at the American Fur Company's Upper Missouri Outfit near the confluence of the Big Sioux and Missouri rivers during 1825-1838 (Johnson 1969). The easternmost historical record for South Dakota was a museum specimen (National Museum of Natural History [NMNH] #300300) collected in 1917, northwest of Pierre in Hughes County.

**Nebraska** – Prior to settlement, the Swift Fox likely occurred in western and central Nebraska (Jones 1964; Hall 1981; Hines and Case 1991). Tallgrass prairies were prevalent in the eastern portion and sand hills of

Nebraska (Risser et al. 1981) and were inconsistent with habitat that is typically occupied by Swift Foxes. In handwritten notes, Merritt Cary, ca. 1905 (manuscript, USFWS, Washington, D.C., see Jones 1964), described some eastern locations in the state. Cary wrote of foxes in Antelope and Madison counties, but there were no specimens. A record from Saline County (M. Cary, ca. 1905, in Jones 1964) is considered questionable (R. Timm, Curator of Mammals, University of Kansas Museum, personal communication). The easternmost verifiable historical records are of four Swift Foxes taken along the Platte River near Fort Kearney, Kearney County, in 1853 (NMNH #A1343-A1348). Historical records from the eastern part of the state largely coincide with the extent of mixed-grass prairie.

**Kansas** – Zumbaugh and Choate (1985) extensively reviewed historical accounts of the Swift Fox in Kansas and identified the species' historical range in the state as corresponding to the shortgrass and mixed-grass prairie regions, bounded in the east by the tall-grass prairies of the Flint Hills. Three museum specimens date back over 100 years. The easternmost historical record in Kansas is a specimen collected in the 1860s in Kingman County, near Chikaskia (NMNH #8538). Other eastern records include a record from Trego County from the 1880s (NMNH #A21663), a record from Ness County in 1901 (near the historical town of Schoharie; American Museum of Natural History [AMNH] #16609), and an account from Rush County in 1861 (Grinnell 1914). The Swift Fox occurred in at least 36 counties and perhaps as many as 44 counties in Kansas (including verified and unverified records; see Zumbaugh and Choate 1985). There are several published accounts (Allen 1874; Knox 1875; Mead 1899; Lantz 1905; Carter 1939) that indicate that the Swift Fox was abundant historically in the high plains of western Kansas.

**Oklahoma** – There are several historical accounts of Swift Foxes in Oklahoma that indicate that the species occurred throughout the panhandle region (Cimarron, Texas, and Beaver counties) and the western portions of three adjacent counties (Harper, Woodward, and Ellis counties; Blair and Hubbell 1938; Duck and Fletcher 1945; Hall 1981; Caire et al. 1989). The first specimens of Swift Foxes from Oklahoma were collected in 1888 from the Neutral Strip, Indian Territory (panhandle; Caire et al. 1989). The Swift Fox was notably absent from records of mammals observed during two expeditions to parts of Oklahoma outside the panhandle region (Irving 1835; Marcy 1854\*). During the first expedition in 1835, Washington Irving joined a military expedition from Fort Gibson in north-eastern Oklahoma to the center of the state. Irving's book, *Tour of the Prairies* (1835), did not include the Swift Fox in its detailed accounting of mammals. In 1852, Captain Randolph B. Marcy explored the Red



River, which defines the present southern border of Oklahoma. The Swift Fox was absent from Marcy's list of encountered mammals (Marcy 1854\*). Moreover, several agencies conducted biological explorations of the lands that were opened to settlers during the Oklahoma land runs of 1889 and 1893 without observation of Swift Foxes. These include exploration by the (1) American Museum of Natural History in western Oklahoma, including near Corumpa and Seneca creeks in the southwestern part of present-day Cimarron County; (2) the Field Museum of Natural History in Chicago in Wood County (Elliot 1899\*); and (3) the US Bureau of the Biological Survey expeditions under E. A. Preble, J. H. Gaut, V. Bailey and D. E. Lanz. These absences suggest that the species' historical range in Oklahoma may have been limited to the far western portion of the state, yet the habitat designations in Risser et al. (1981) showed potentially suitable habitats further east. Biotic districts described by Blair and Hubbell (1938) are finer-scaled habitat designations for Oklahoma that show the shortgrass plains district transitioning through sand areas to the mixed-grass plains district. The eastern boundary of the shortgrass plains district in Oklahoma is a distinct and abruptly rising scarp. The historical range for Swift Foxes in Oklahoma may have been somewhat contained by this biotic district.

**Texas** – Egoscue (1979), Hall (1981), and Jones et al. (1987\*) defined the historical range of the Swift Fox in Texas as the panhandle region south into the west-central portion of the state; approximately 78 counties were included. Bailey (1905) provided the first published report of Swift Foxes in Texas; he examined five Swift Foxes from Martin County (one stored at NMNH #126222) and also reported on Swift Foxes from Midland, Oldham, and Armstrong counties. Jones et al. (1987\*) indicated that only 28 counties in Texas had reliable records of Swift Foxes, based on the literature, trapping records, and museum specimens. They estimated that half of the historical range, as defined in earlier literature (e.g., Egoscue 1979; Hall 1981), was no longer suitable for the species due to conversion of grassland to intensive agriculture (high plains below the 34th parallel). Certainly, Swift Foxes occurred in other counties lacking recorded observations or specimens, but there is a striking absence of records from the grassland type defined by Risser et al. (1981) as the southern mixed-grass prairie with shrubs (see Sovada and Scheick 1999\*). This absence provides further evidence of Swift Fox avoidance of habitats with taller structure. Similar to the shifting nature of the boundary between mixed-grass and tall-grass prairies described above, encroachment of shrubs in the southern mixed-grass prairie (Archer 1994) likely influenced Swift Fox distribution.

**New Mexico** – In the plains-mesa grasslands of New Mexico, Swift Foxes likely occurred in 12 counties

(Dick-Peddie 1993), including Colfax, Union, Mora, Harding, San Miguel, Guadalupe, Quay, De Baca, Curry, Roosevelt, Chaves, and Lea counties (Kahn et al. 1997\*). Bailey (1931), Egoscue (1979), and Hall (1981) described the species as occurring east of the Pecos River drainage in the extreme eastern portion of New Mexico. The first record of the Swift Fox in New Mexico was a skull collected in 1879 near Cabra Spring in San Miguel County (NMNH #16240). Seton (1929) reported collecting a Swift Fox near Clayton in Union County (between October 1893 and February 1894; see also Caire et al. 1989). There are no records of Swift Foxes in New Mexico from 1894 to 1952, except for a single report from Santa Rosa labeled *V. macrotis* (i.e., Kit Fox), which Bailey (1931) believed was a Swift Fox. A museum specimen (Museum of Southwest Biology [MSB], University of New Mexico, #BRD101289) identified as *V. velox*, collected in 1928 about 13 km southwest of Albuquerque, which is substantially outside all estimates of the historical range of the Swift Fox, was recently examined and identified as *V. macrotis* (R. Harrison, University of New Mexico, Albuquerque, personal communication). There is range overlap with the Swift Fox's close relative, the Kit Fox, in the Trans-Pecos region of New Mexico, where the two species are known to hybridize (Mercure et al. 1993). Hubbard (1994\*: 4) concluded that the hybrid zone for the two species "appeared to be restricted to an area not exceeding 50–60 miles [80.5–96.6 km] in width in the Pecos Basin of New Mexico." It is important to note, as Hubbard (1994\*: 5) reported, that the contact zone between Swift and Kit foxes "is as enduring as it is broad", existing for several thousand years, yet abrupt morphological differences between Swift and Kit foxes exist in this zone.

**Colorado** – The Swift Fox was reported as common in the shortgrass and mixed-grass prairie regions in the eastern half of Colorado (e.g., Cary 1911; Armstrong 1972; Hall 1981). Cary (1911) recounted an 1895 report that indicated that Swift Foxes were rare in the Loveland area of Larimer County in north-central Colorado. Earliest accounts in Colorado included observations of the "prairie fox" near Bent's Fort (Otero County in southeastern Colorado) in notes from a military reconnaissance in 1848 (Emory 1848\*). A museum specimen was collected in Bent County in 1889 (NMNH #187994-5). Western historical locations were documented by museum specimens collected in 1878, including one in Denver County (AMNH #24419) and another in El Paso County near Colorado Springs (AMNH #24420). A fox was killed 4.8 km northeast of Boulder (Boulder County) in north-central Colorado in 1903 (Cary 1911). Cary (1911) recounted a report of two Swift Foxes shot near Arapahoe Creek (Jackson County) in 1893, but Armstrong (1972) was skeptical of this account because the habitats seemed unsuitable. Although it is possible that Swift Foxes pioneered into North Park

TABLE 2. The estimated area of Swift Fox historical range, the area of habitats that are currently suitable<sup>a</sup> within that range, and the area of suitable habitats that are occupied by Swift Foxes as determined from surveys conducted 2001–2006.

	Grassland						Cropland					
	High quality			Medium quality			Medium quality			Low quality		
	Area of historical range km <sup>2</sup>	Available in historical range km <sup>2</sup>	% <sup>c</sup>	Occupied counties or blocks <sup>b</sup> km <sup>2</sup>	Available in historical range km <sup>2</sup>	% <sup>c</sup>	Occupied counties or blocks <sup>b</sup> km <sup>2</sup>	Available in historical range km <sup>2</sup>	% <sup>c</sup>	Occupied counties or blocks <sup>b</sup> km <sup>2</sup>	Available in historical range km <sup>2</sup>	% <sup>c</sup>
<b>United States</b>												
Colorado	108 244	41 848	39	34 275	3 203	3	2 728	34 349	32	29 671	10 000	9
Kansas	119 952	31 213	26	12 831	8 171 <sup>e</sup>	7	4 890	45 214	38	22 298	22 279	19
Montana	199 520	92 124	46	48 355	36 556	18	18 561	33 725	17	17 584	15 777	8
Nebraska	88 357	37 149	42	10 088	677	1	0	10 270	12	2 463	24 241	27
New Mexico	47 600	32 918	69	30 669	5 881	12	4 268	1 192	3	310	555	1
North Dakota	167 239	33 484	20	0	30 134	18	0	0	0	0	75 917	45
Oklahoma	31 459	14 070	45	10 533	5 667	18	3 928	7	7	7	10 212	32
South Dakota	164 338	77 826	47	47 382	23 722	14	11 825	0	0	0	46 232	28
Texas	86 155	33 116	38	3 442	9 752	11	714	360	0	0	25 878	30
Wyoming	72 757	32 366	44	25 205	19 725	27	16 507	5 909	8	5 569	3 590	5
Subtotal	<b>1 085 621</b>	<b>426 114</b>	<b>39</b>	<b>222 780</b>	<b>143 488</b>	<b>13</b>	<b>63 421</b>	<b>131 026</b>	<b>14</b>	<b>77 902</b>	<b>234 681</b>	<b>22</b>
<b>Canada</b>												
Alberta	89 118	53 290	60	2 396	1 413	2	85	39 735	45	60	—	—
Saskatchewan	239 297	76 237	32	4 139	4 790	2	83	169 266	71	3 176	—	—
Manitoba	34 021	10 284	30	0	420	1	0	20 019	59	0	—	—
Subtotal	<b>362 436</b>	<b>139 811</b>	<b>39</b>	<b>6 535</b>	<b>6 623</b>	<b>2</b>	<b>168</b>	<b>229 020</b>	<b>63</b>	<b>3 236</b>	<b>—</b>	<b>—</b>
<b>Total U.S. and Canada</b>	<b>1 448 057</b>	<b>565 925</b>	<b>39</b>	<b>229 315</b>	<b>150 111</b>	<b>10</b>	<b>63 589</b>	<b>360 046</b>	<b>25</b>	<b>81 138</b>	<b>234 681</b>	<b>16</b>
											<b>54 733</b>	<b>23</b>

<sup>a</sup> High-quality grassland habitats: short to mid-height perennial grassland habitats.  
Medium-quality grassland habitats: mid-height to tall perennial grassland habitats with sparse shrub component.  
Medium-quality cropland habitats: suitable agricultural lands, with predominantly dryland cropping practices.  
Low-quality cropland habitats: cropland marginally suitable or of unknown suitability.  
<sup>b</sup> In the United States, the sample unit is county. In Canada, the sample unit is a block 93 km<sup>2</sup> (see Methods for description).  
<sup>c</sup> Percentage of the area of historical range.  
<sup>d</sup> Percentage of the habitat available in the historical range.  
<sup>e</sup> Conservation Reserve Program lands planted mostly to tallgrass species, which provide low quality perennial grassland habitat for Swift Foxes.



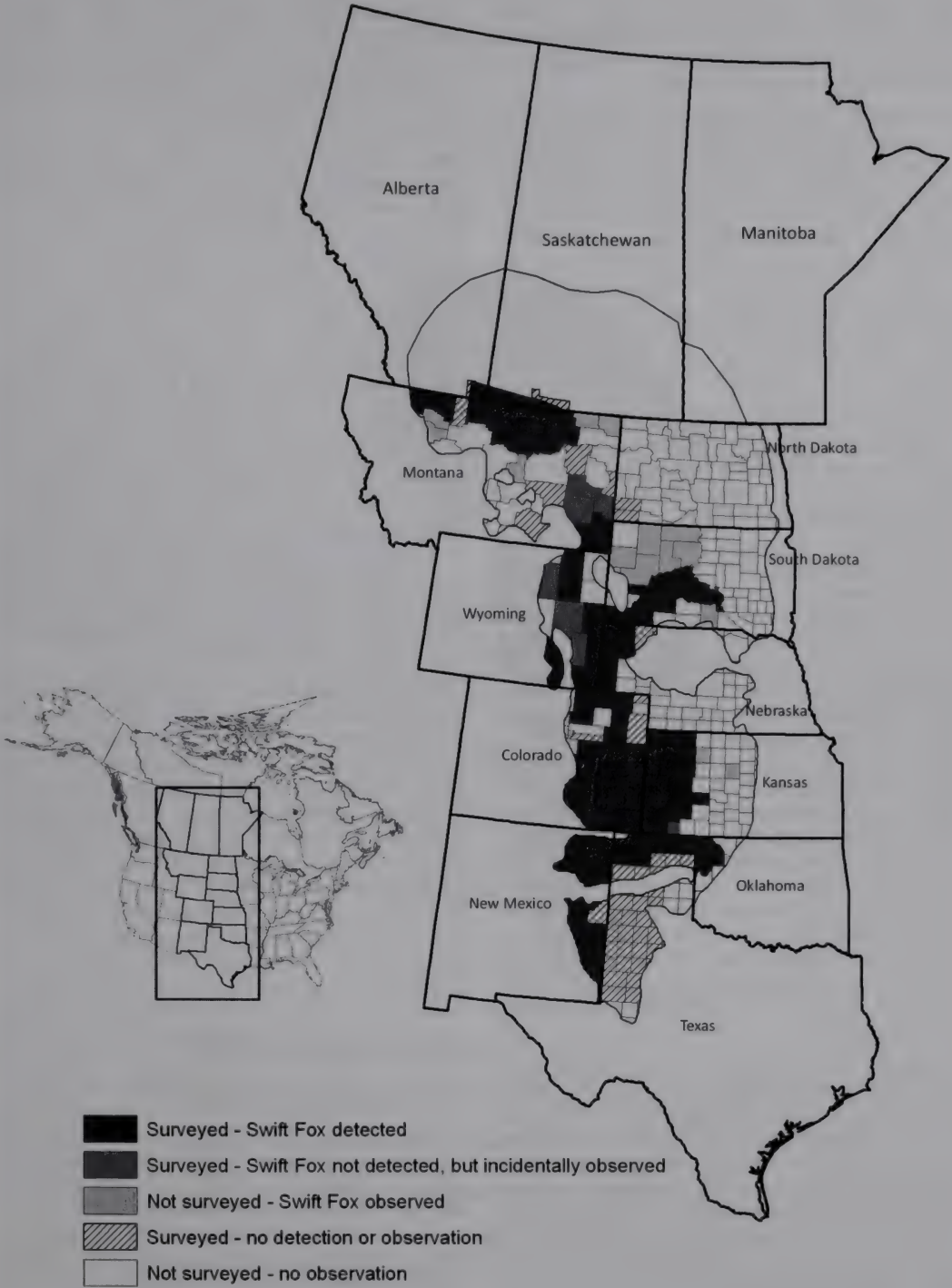


FIGURE 2. Recent occurrences of Swift Fox by county in the United States and the surveyed area in Canada (Moehrensclager and Moehrensclager 2006\*), bounded by the estimate of the species' historical range. Swift Fox occurrences in the United States are from survey results, confirmed observations, and fur-harvest records, 2001–2006. Swift Fox occurrences in Canada are from live-trap surveys and incidental observations, 2005–2006.

(Colorado basin) from nearby Carbon County in Wyoming, along the North Platte River valley, if Swift Foxes did occur in Jackson County, Colorado, they likely were rare and only occasional occupants on the fringe of the species' distribution.

**Wyoming** – In Wyoming, published records position the western edge of the species' historical distribution along the eastern portions of Carbon, Johnson, Natrona, and Sheridan counties (Long 1965; Hall 1981; Lindberg 1986). Museum specimens were collected near Cheyenne, Laramie County, in 1870 (Yale Peabody Museum #YPM37); near Fort Laramie, Goshen County, in the 1880s (NMNH #A16460); and near Bridger Pass, Carbon County, in 1856 (NMNH 1871). Five specimens were collected near Aurora Lake, Carbon County, in 1891 (AMNH #14499-14503).

**Montana** – In Montana, the Swift Fox was once considered common in the shortgrass to mixed-grass prairies east of the Rocky Mountains (Kahn et al. 1997\*; Knowles et al. 2003). Meriwether Lewis and William Clark observed Swift Foxes during their expedition along the Marias and Missouri rivers in 1805 and 1806 (Burroughs 1961). In the late 1800s, Coues (1878) reported that Swift Foxes were common between the Milk River in Montana and the Canadian border. There are many other reports of Swift Foxes in Montana in the late 1800s and early 1900s (e.g., Audubon and Bachman 1854; Allen 1874; Grinnell 1875\*; McChesney 1879\*; see Knowles et al. 2003). Westernmost historical records are from Glacier (1806, Lewis and Clark in Knowles et al. 2003), Pondera (1894, NMNH #67599), Toole (1905, NMNH #146372), and Cascade (Lewis and Clark 1805 in Knowles et al. 2003) counties. The last historical record of Swift Foxes in Montana was in 1918, when Bailey and Bailey (1918) noted that the Swift Fox commonly occurred on the plains along the eastern edge of Glacier National Park. Hoffman et al. (1969) considered the species extirpated in Montana after a 16-year absence in fur harvest records. The next Swift Fox record was an individual captured in Custer County in 1978 (Moore and Martin 1980).

**Canada** – The Swift Fox was once a common species in the southern prairie regions of Canada, but by the 1930s, it was considered nearly extinct (Anthony 1928) or extinct (Stewart 1974; Carbyn et al. 1994). The historical distribution of the species in Canada corresponds to the shortgrass or mixed-grass prairie regions of southwestern Manitoba, southern Saskatchewan, and southeastern Alberta (Soper 1964; Banfield 1974; Carbyn et al. 1994). Soper (1964) bounded the northern- and westernmost distribution in Alberta along the 53rd parallel and west to the foothills of the Rocky Mountains. In Saskatchewan, its northern distribution extended to the Saskatchewan River (also near the 53rd parallel; Carbyn et al. 1994). There are no verified records of Swift Foxes in Manitoba, but it is

likely that the species occasionally occurred in the southwestern corner based on fur harvest records from northeastern North Dakota (Carbyn et al. 1994). Several publications (e.g., Anthony 1928; Anderson 1946; Miller and Kellogg 1955; Hall 1981) indicated that the range of the Swift Fox crossed the mountains of western Montana and extended into southeastern British Columbia, but the authors provided no evidence. This determination was contradicted by Soper (1964) and Hoffmann et al. (1969), who did not list the species as part of British Columbia's fauna; there are no known historical or contemporary records of the Swift Fox in British Columbia (Egoscue 1979). Museum records for Alberta include a Swift Fox collected in 1878 from near Medicine Hat (NMNH #187993); four foxes collected from "Medicine Hat-Assiniboine" in 1894 (NMNH #69460-69462); one collected near Calmali in 1894 (NMNH #69463); and six collected in the Calgary area in 1900-1901 (NMNH #108255-108259, 108261). The foxes from the Calgary area were collected by W. G. Mackay and G. F. Dippie, owners of a furhouse, and thus the collection location of these specimens is unclear, but likely in the Calgary area. The last confirmed record of Swift Fox in Canada prior to the 1983 reintroduction program (discussed below) was a specimen (Royal Ontario Museum #2803170005) taken in 1928 near Govenlock, Saskatchewan (Carbyn 1998\*).

**Minnesota and Iowa** – It is difficult to assess the historical distribution of the Swift Fox in Minnesota and Iowa based on available information. There are no known records of Swift Foxes in Minnesota (E. Birney, Bell Museum of Natural History, University of Minnesota, personal communication). Nevertheless, several authors have included Minnesota in the historical range of the species (Hall and Kelson 1959; Hawley 1974; Hillman and Sharps 1978; Egoscue 1979; Hazard 1982; Carbyn et al. 1994). The inclusion of Minnesota as part of the historical distribution has been accepted implicitly, but the evidence for this assertion has been elusive. The claim may have been based on speculation by Swanson et al. (1945: 71), who suggested that since the Swift Fox is found throughout North Dakota, it "... occasionally ventured into Minnesota." Despite a complete absence of confirmed or unconfirmed sightings in Minnesota, the speculation by Swanson et al. (1945) clearly has merit, because environmental conditions on the tallgrass prairies of western Minnesota occasionally may have been suitable for Swift Foxes (see Discussion). In Iowa, there are no verified records, although, without stated evidence, Swift Fox occurrence was indicated in a mammal list (Allen 1942 in Hines 1980) and in several range maps (Hall and Kelson 1959; Hawley 1974; Hillman and Sharps 1978; Carbyn et al. 1994). Dinsmore (1994) presented a comprehensive account of possible Swift Fox occurrences in Iowa since European settlement, including observations in Sac and Pocahontas





FIGURE 3. Low-, medium-, and high-quality habitats mapped using digital data provided by GAP analysis (<http://gapanalysis.nbi.gov/portal/server.pt>) in the United States and by the National Land and Water Information Service (Government of Canada 2008\*) in Canada. Suitability for Swift Fox occupation is based on information from the literature and expert opinion (see Appendix).

counties in the mid-1800s and Dickinson County in 1882. Descriptions from some of these reports may fit the Swift Fox, but inconsistent use of common names and lack of a specimen contribute to the confusion (Dinsmore 1994). No records of Swift Foxes exist for counties in South Dakota or Nebraska that are adjacent to Iowa. As with Minnesota, Swift Foxes may have occurred intermittently and in low densities in the far western portions of Iowa when habitat conditions were suitable.

#### *Estimates of the Historical, Current, and Potential Distributions*

Assimilating the records described above with habitat requisites of the Swift Fox results in an estimate of a historical range that was substantially larger than the current distribution. The estimated area with habitat suitable for Swift Foxes prior to settlement is approximately 1 085 621 km<sup>2</sup> in the United States and 362 436 km<sup>2</sup> in Canada (Appendix). A synthesis of Swift Fox survey data collected during 2001–2006 indicates that the species occupies approximately 44% of its historical range in the United States and 3% in Canada (Figure 2). The area searched for signs of occupancy comprised 48% of the historical range in the United States and 4% in Canada. Parts of the historical range were not surveyed systematically during 2001–2006, largely because it was not economically wise to search areas known to be vacant for many years or areas disconnected from existing populations. Rather, surveys focused on areas of known occupancy and those adjacent to areas of known occupancy. Herein, the assumption is that unsurveyed areas were not occupied by Swift Foxes.

The area within the historical range containing short-structured grasslands most suitable (i.e., high-quality habitat category) for Swift Fox occupancy is 426 115 km<sup>2</sup> in the United States and 139 811 km<sup>2</sup> in Canada, comprising 39% of the historical range overall (Table 2, Figure 3). Grasslands with a short, sparse shrub component (i.e., medium-quality habitat) suitable for use by Swift Foxes occurs in 10% of the historical range, and cropland dominated by dryland agricultural practices with potential for use by Swift Foxes occurs in at least 25% of the historical range. In the United States, approximately 52% of highest quality habitats currently available are occupied by Swift Foxes.

#### **Discussion**

The Swift Fox is considered an important indicator species for the former extent of shortgrass and mixed-grass prairies; this reflects the species' strong association with short-structured grasslands (Egoscue 1979). Data on current habitat use and preferences, in conjunction with historical records and published information, support the assertion that the pre-settlement distribution of the Swift Fox was largely limited to the shortgrass and mixed-grass ecosystems. By definition,

the Swift Fox should encounter the boundary of its realized niche at the edge of its range, where environmental conditions are less than ideal and habitat quality declines (*sensu* Kanda et al. 2009). Grassland ecosystems, however, are inherently dynamic, and the edges of the historical range of the Swift Fox undoubtedly were pliant and reflected prevailing environmental conditions. When environmental conditions changed along the species' distributional boundary, the suitability of the grassland habitat likely changed as well. Thus, defining the historical range limit of the Swift Fox with any precision may be impossible. Nonetheless, some publications (e.g., Hall 1981; Scott-Brown et al. 1987) probably have overstated the extent of the species' historical range by as much as 20–25% (see Kahn et al. 1997\*). Swift Foxes likely occupied areas of the tallgrass prairie during some years or periods, when the vegetation was shorter than average (e.g., during prolonged drought, changes in grazing pressure), but these limited and occasional occupations did not represent areas of sustained occupation, and inclusion in the estimates of the species' historical range is not supported by the species' habitat preferences.

North American grasslands have experienced significant changes since European settlement, and the Swift Fox has survived and adapted to vastly changed land use. The once expansive grasslands in the Swift Fox's historical range are now typically fragmented or degraded. Habitat composition can vary significantly, and suitability for Swift Fox occupation can be difficult to define. Consider, for example, that Swift Foxes are adequately supported in crop-dominated landscapes with a grassland component if the agricultural practices are dryland farming (Kilgore 1969; Hines 1980; Shaughnessy 2003; Sovada et al. 2003). Even though Swift Foxes are considered a hallmark species of short-structured grasslands, the intensity and system of mixed agricultural/rangeland landscape do not necessarily diminish the habitat value. But agricultural cropping practices changing from dryland farming to more irrigation and large monotypic crop fields are more common; such changes likely will not benefit Swift Foxes that presently are able to use fallow fields for foraging and denning.

The species' recovery, which began in the 1950s, proceeded slowly as Swift Foxes dispersed from remnant populations to reoccupy parts of the central and southern portions of the historical range. Early on, this reoccupation was assisted by a decline in the intensity of human-caused mortalities (e.g., poisoning, trapping). Yet, pioneering by Swift Foxes northward in their historical range was not evident, even though suitable habitats were available. Factors limiting or delaying the expansion of Swift Foxes into unoccupied parts of their historical range are unknown and may be key to conservation of this species. Swift Foxes are opportunistic foragers, using a wide variety of food items, including small mammals, birds, insects, reptiles,



and carrion (Kilgore 1969; Scott-Brown et al. 1987). The generalist foraging behaviors of Swift Foxes make food an unlikely limiting factor, and there is no evidence to support food availability as a reason for limiting population expansion.

There are two possible reasons for the inability of Swift Foxes to achieve marked expansion into suitable areas within their historical range. First, Swift Foxes may simply be poor colonizers. Dispersing Swift Foxes are at risk of mortality as they move through unfamiliar areas seeking an area for settlement, and pioneers may have difficulty finding mates in newly colonized areas. Significant changes in landscape (increased agriculture, lack of corridors) may also result in increased risk of predation. Second, interspecific competition with Red Foxes and Coyotes could inhibit pioneering Swift Foxes from going into areas occupied by either of these species, creating an ecological barrier for settlement into new areas. There have been marked changes in the canid community within the historical range of the Swift Fox, lending support to this possibility. When Swift Foxes apparently thrived in the region, the canid community was dominated by wolves; presently it is dominated by Red Foxes and Coyotes (Johnson and Sargeant 1977). There is considerable evidence that interspecific competition, often as interference competition, acts as a mechanism regulating spatial distribution and population size among canid species (Carbyn 1982; Rudzinski et al. 1982; Sargeant et al. 1987; Bailey 1992; Ralls and White 1995).

The northward expansion of the Swift Fox into Montana, South Dakota, and southern Canada has been facilitated by reintroduction programs. Four reintroduction programs have been completed and are considered successful (i.e., achieved population growth rate of  $\geq 1$  and an index count of  $\geq 100$  Swift Foxes). The first was conducted by the Canadian Wildlife Service and cooperators (Carbyn et al. 1994). They released Swift Foxes annually from 1983 until 1997, on privately owned grasslands and community pastures in Alberta and Saskatchewan. Swift Foxes expanded their distribution from these release sites, and they have recolonized areas along the US-Canada border in north-central Montana (Zimmerman et al. 2003; Moehrenschrager and Moehrenschrager 2006\*).

The second successful reintroduction effort (1998–2002) occurred on Blackfeet Tribal lands, east of Glacier National Park, in north-central Montana (Ausband and Foresman 2007). This reintroduction effort was followed by reintroductions at two sites in South Dakota, both completed in 2007. The first, funded by the Turner Endangered Species Fund, is located on the Bad River Ranch and surrounding areas in central South Dakota (Honness 2007\*; Honness and Phillips 2007\*). The second South Dakota effort occurred at Badlands National Park and Buffalo Gap National Grassland, which is approximately 100 km southwest of the Bad River Ranch (Sovada et al. 2006\*; Schroe-

der 2007). The expectation is that, as the two populations grow, they will merge, and westward expansion will result in a merger with an isolated native population near Ardmore, South Dakota. As evidence of this, two male Swift Foxes released on Bad River Ranch have come in contact with Badlands National Park Swift Foxes (G. Schroeder, US National Park Service, personal communication) and one is believed to have mated with a Badlands female fox in the 2006 breeding season. Additionally, a male fox from Badlands National Park dispersed away from the park (approximately 110 km) and was confirmed to have mated with a female fox in the Ardmore area; they raised a litter of pups in 2005 (G. Schroeder, US National Park Service, personal communication). Thus, three populations have begun to intersperse breeding in central to southwestern South Dakota.

There are three ongoing reintroduction efforts for which it is too early to predict their outcomes: (1) Lower Brule Sioux Tribal lands (begun in 2006, South Dakota; Grassel 2007\*), (2) Fort Peck Tribal Lands (begun in 2006, Montana; Kunkel et al. 2007\*), and (3) Kainai (Blood Tribe) First Nation lands (begun in 2004, Alberta, Canada; Smeeton 2006\*).

Determining the current distribution of a native species is less enigmatic than defining its historical range, but such information is, nevertheless, difficult to attain. Yet, a measure of population status and trends has relevance to the conservation of the species. Expansion or contraction in distribution of the species can inform management agencies of trends in a population on a large scale. For the Swift Fox, management agencies of individual states have identified methods for monitoring populations that they can afford to apply within a five-year schedule. Kansas, Montana, and Oklahoma conduct extensive surveys that are relatively inexpensive. These states use townships ( $93 \text{ km}^2$ ) as the sample unit, surveying approximately half the townships in the region of the survey (e.g., for Kansas, the region is about one-third of the state). With these data, it is appropriate to apply Markov chain Monte Carlo image restoration analyses to provide an estimate of the underlying distribution rather than just an atlas map of presence or absence (Sargeant et al. 2005). In contrast, North Dakota, a state with no known breeding population of Swift Foxes, relies on less extensive track surveys in areas of expected presence of Swift Foxes dispersing from established nearby populations and incidental observations provided by the general public, trappers, and state agency personnel. Additionally, articles are published in local magazines asking trappers and the public for their cooperation in reporting sightings (e.g., Sovada 2008\*). There is marked variation in the intensity and extent of surveys conducted by each agency, yet efforts are appropriate based on resources and the status of the population within an agency's jurisdictions. The sharing of survey results by agencies facilitates the ability of managers to detect

significant change in population status throughout the range.

Although state and provincial management agencies have employed several approaches to monitoring Swift Foxes, the county-level map of occurrence (Figure 2) provides a simple but practical approach across the entire range of the species. With county-level data collected approximately every five years, management agencies can gain information on expansion, contraction, or stability in distribution. Contractions in distribution or isolation of populations would alert the managing agencies to potential threats to the health of populations. In contrast, stable or expanding distribution should reassure agencies that management actions may have been effective.

The first range-wide survey in the United States was conducted by state agencies during 1995–1999 (Sovada and Assenmacher 2005\*). These surveys were conducted with the same methods as the 2001–2006 surveys, and results were also reported by county occupancy, as presented herein for the 2001–2006 surveys. Summaries of the 1995–1999 data indicate Swift Foxes occupied 39% of the historical range during that period. Results from the 2001–2006 surveys indicate a 5% increase in the area occupied, suggesting relative stability or an expanding population.

Since the 2001–2006 surveys, evidence of Swift Foxes dispersing into unoccupied areas of their historical range suggests progressive expansion. In South Dakota, Schroeder and Jenks (2008\*) reported significant pioneering of Swift Foxes from the reintroduced Badlands population into unoccupied areas in the state. There also is compelling evidence that individuals from the reintroduced populations from South Dakota and Montana are expanding into North Dakota. In the last three years, six Swift Foxes were recovered (killed by vehicles or trapped) in southwestern North Dakota (Bowman [3], Slope [1], Morton [2] counties), one Swift Fox was recovered in north-central North Dakota (Bottineau County), and another was found in 2007 just across the eastern border of North Dakota in western Minnesota (Clay County). This is the first confirmed record of a Swift Fox in Minnesota. Four of the eight recovered Swift Foxes were tagged and linked to reintroduction sites in South Dakota; one of these was a wild-born fox. The remaining four recovered Swift Foxes had not been tagged, indicating dispersal from wild populations or at least one generation post-release from a reintroduced population. The recoveries in North Dakota represent a notable increase in the number of Swift Fox observations in the state; the Swift Fox was not reported in North Dakota between 1915 and 1970, and only four records were recorded between 1970 and 1994. Although there is no evidence of a breeding population in North Dakota, the recent observations in North Dakota and a known breeding pair in adjacent Perkins County, South Dakota (Schroeder and Jenks 2008\*) provide support

for this species eventually re-establishing a breeding population in North Dakota and perhaps in southeastern Saskatchewan and southwestern Manitoba.

In conclusion, we evaluated the distribution and status of the Swift Fox across its historical range in the United States and Canada. The Swift Fox currently occupies less than one-half of its former range, an area that once covered over 1.5 million km<sup>2</sup> of the mid-continent. Although loss, fragmentation, and degradation of prairie habitats since European settlement have undoubtedly compromised the potential distribution of this species, the Swift Fox currently occupies a greater percentage of its historical range than it did in the mid-1900s. For instance, consider that, during the 20th century, the species was deemed extirpated from Canada (Carbyn et al. 1994) and five states: Kansas and Oklahoma (Cockrum 1952), Nebraska (Jones 1964), Montana (Hoffmann et al. 1969), and North Dakota (Jones and Birney 1988). Several other states lacked observations of Swift Foxes for decades (Texas 1905–1948; Colorado 1916–1941; Wyoming 1898–1958; South Dakota 1914–1966; Sovada and Scheick 1999\*). Once poisoning and other significant sources of mortality were suppressed, dispersal and reintroduction into unoccupied but suitable habitats facilitated recovery of the Swift Fox in parts of its former range (Moehrenschrager et al. 2004; Allardyce and Sovada 2003). In particular, the success of Swift Fox reintroductions in the northern parts of the species' range confirm that there are unoccupied areas with adequate resources to support Swift Foxes and that viable populations can be sustained once local populations attain sufficient numbers.

These successes in population growth and reoccupation of former range should not dissuade proactive measures to promote continued conservation and recovery of the species. Grassland habitats continue to be lost, fragmented, and degraded, and extirpation and isolation of local populations remain a concern. Although the Swift Fox tolerates some modification of landscapes, it is not yet known what degree of alteration is tolerable (e.g., ratio of grassland to agriculture, connectivity of grasslands; Moehrenschrager and Sovada 2004). Recovery strategies for this species will depend on integrating actions at the state, national, and continental levels, and wildlife management agencies in the United States and Canada must remain vigilant to ensure the species' population viability and the desired level of recovery established in management plans.

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Appendix

Area (km<sup>2</sup>) of Swift Fox historical range and available habitats suitable for Swift Fox occupation within its historical range by state and province. Habitats are those classified in GAP analysis for individual states (USGS National GAP Analysis Program, <http://gapanalysis.nbi.gov/portal/server.pt>) and, for Canada, the National Land and Water Information Service (Government of Canada 2008\*).

Habitat categories <sup>a</sup>	Historical range (total km <sup>2</sup> )	Grassland land cover		Agricultural land cover	
		High quality <sup>b</sup>	Medium quality <sup>c</sup>	Medium quality <sup>d</sup>	Low quality <sup>e</sup>
<b>Montana</b>	199 520				
Agricultural lands (dry)				33 725	
Agricultural lands (irrigated)					15 777
Altered herbaceous			8 700		
Very low cover grasslands		8 140			
Low/moderate cover grasslands		73 688			
Moderate/high cover grasslands		9 559			
Mixed xeric shrubs			9 405		
Silver sage		737			
Salt-desert shrub/dry salt flats			1 211		
Sagebrush			10 597		
Mesic shrub-grassland associations			2 006		
Xeric shrub-grassland association			4 637		
<b>Total</b>		<b>92 124</b>	<b>36 556</b>	<b>33 725</b>	<b>15 777</b>
<b>North Dakota</b>	167 239				
Cropland					75 917
Planted herbaceous			28 920		
Prairie (mesic tallgrass mix)		2 054			
Prairie (bluestem-needlegrass-wheatgrass)		5 472			
Prairie (wheatgrass)		8 259			
Prairie (needlegrass)		7 392			
Prairie (little bluestem)		4 298			
Prairie (fescue)		444			
Prairie (sand)		4 165			
Prairie (saline)		1 400			
Shrubland sagebrush			903		
Sparse vegetation others			311		
<b>Total</b>		<b>33 484</b>	<b>30 134</b>	<b>0</b>	<b>75 917</b>
<b>South Dakota</b>	164 338				
Agriculture					46 232
High cover grassland			13 868		
Low cover grassland		40 157			
Medium cover grassland		19 163			
Sand hills, sparse vegetation			312		
Shale barren slope, sparse vegetation			717		
Xeric shrubland			44		
Mesic shrubland			344		
Deciduous shrubland			33		
Hayland			2 013		
Idle grassland			6 391		
Pastureland		18 506			
<b>Total</b>		<b>77 826</b>	<b>23 722</b>	<b>0</b>	<b>46 232</b>
<b>Wyoming</b>	72 757				
Mountain big sagebrush			167		
Grass-dominated riparian			606		
Mixed-grass prairie		32 252			
Irrigated crops					3 590
Wyoming big sagebrush			17 975		
Dryland crops				5 909	
Grass-dominated wetland			6		
Shortgrass prairie		114			
Xeric upland shrub			971		
<b>Total</b>		<b>32 366</b>	<b>19 725</b>	<b>5 909</b>	<b>3 590</b>

## Appendix (continued)

Area (km<sup>2</sup>) of Swift Fox historical range and available habitats suitable for Swift Fox occupation within its historical range by state and province. Habitats are those classified in GAP analysis for individual states (USGS National GAP Analysis Program, <http://gapanalysis.nbi.gov/portal/server.pt>) and, for Canada, the National Land and Water Information Service (Government of Canada 2008\*).

Habitat categories <sup>a</sup>	Historical range (total km <sup>2</sup> )	Grassland land cover		Agricultural land cover	
		High quality <sup>b</sup>	Medium quality <sup>c</sup>	Medium quality <sup>d</sup>	Low quality <sup>e</sup>
<b>Nebraska</b>	88 357				
Sandsage shrubland			677		
Little bluestem-gramma mixed-grass prairie		21 846			
Western wheatgrass mixed-grass prairie		207			
Western shortgrass prairie		15 096			
Agricultural fields					24 241
Fallow agricultural fields				10 270	
<b>Total</b>		<b>37 149</b>	<b>677</b>	<b>10 270</b>	<b>24 241</b>
<b>Colorado</b>	108 244				
Dryland crops				34 349	
Irrigated crops					10 000
Tallgrass prairie			1 897		
Sand dune complex (grassland)			538		
Midgrass prairie		3 412			
Shortgrass prairie		38 436			
Foothill/mountain grassland			767		
Mesic upland shrub			0		
Xeric upland shrub			1		
<b>Total</b>		<b>41 848</b>	<b>3 203</b>	<b>34 349</b>	<b>10 000</b>
<b>Kansas</b>	119 952				
Sand prairie		982			
Western wheatgrass prairie		3 132			
Mixed prairie		19 525			
Shortgrass prairie		7 574			
Conservation Reserve Program Land			8 171		
Dryland crops <sup>f</sup>				45 214	
Other cultivated land					22 269
Weedy upland					10
<b>Total</b>		<b>31 213</b>	<b>8 171</b>	<b>45 214</b>	<b>22 279</b>
<b>Oklahoma</b>	31 459				
Sandsage prairie		2 218			
Gypsum grasslands			379		
Midgrass sand prairie			3 625		
Midgrass sandsage prairie		985			
Midgrass prairie		4 610			
Grass-buffalograss prairie		6 056			
Agriculture				7	
Crop (warm season)					10 212
Improved/introduced pasture (warm season)		201			
Sandsage savanna			1 663		
<b>Total</b>		<b>14 070</b>	<b>5 667</b>	<b>7</b>	<b>10 212</b>
<b>Texas</b>	86 155				
Cropland (irrigated, row, herbaceous, etc.)					25 878
Microphyllous evergreen shrubland			2 712		
Lowland mixed evergreen-drought deciduous shrubland			3 947		
Medium-tall bunch temperate or subpolar grassland		10 701			
Temperate or subpolar grassland with a sparse shrub layer		4 433			
Semipermanently flooded temperate or subpolar grassland			345		
Short sod temperate or subpolar grassland		17 982			
Annual graminoid or forb vegetation				360	
Intermittently flooded temperate or subpolar grassland (e.g., Playa Lakes)			1 341		
Round-crowned temperate or subpolar needle-leaved evergreen woodland			1 295		
Temperate broad-leaved evergreen shrubland			112		
<b>Total</b>		<b>33 116</b>	<b>9 752</b>	<b>360</b>	<b>25 878</b>



## Appendix (continued)

Area (km<sup>2</sup>) of Swift Fox historical range and available habitats suitable for Swift Fox occupation within its historical range by state and province. Habitats are those classified in GAP analysis for individual states (USGS National GAP Analysis Program, <http://gapanalysis.nbii.gov/portal/server.pt>) and, for Canada, the National Land and Water Information Service (Government of Canada 2008\*).

Habitat categories <sup>a</sup>	Historical range (total km <sup>2</sup> )	Grassland land cover		Agricultural land cover	
		High quality <sup>b</sup>	Medium quality <sup>c</sup>	Medium quality <sup>d</sup>	Low quality <sup>e</sup>
<b>New Mexico</b>	47 600				
Plains-mesa broadleaf sand-scrub			4 713		
Chihuahuan desert scrub			114		
Chihuahuan broadleaf deciduous desert scrub			578		
Shortgrass steppe		17 731			
Mid-grass prairie		15 187			
Chihuahuan desert grassland			402		
Chihuahuan foothill-piedmont desert grassland			74		
Dryland agriculture				1 192	
Irrigated agriculture					555
Basin/playa			0		
<b>Total</b>		<b>32 918</b>	<b>5 881</b>	<b>1 192</b>	<b>555</b>
<b>U.S. TOTAL</b>	<b>1 085 621</b>	<b>426 114</b>	<b>143 488</b>	<b>131 026</b>	<b>234 681</b>
% of historical range		39.25%	13.22%	12.07%	21.62%
<b>Alberta</b>	89 118				
Shrubland			1 413		
Grassland		38 560			
Agriculture (cropland)				39 735	
Agriculture (pasture/forage)		14 730			
<b>Total</b>		<b>53 290</b>	<b>1 413</b>	<b>39 735</b>	
<b>Saskatchewan</b>	239 297				
Shrubland			4 790		
Grassland		39 837			
Agriculture (cropland)				169 266	
Agriculture (pasture/forage)		36 400			
<b>Total</b>		<b>76 237</b>	<b>4 790</b>	<b>169 266</b>	
<b>Manitoba</b>	34 021				
Shrubland			420		
Grassland		7 949			
Agriculture (cropland)				20 019	
Agriculture (pasture/forage)		2 335			
<b>Total</b>		<b>10 284</b>	<b>420</b>	<b>20 019</b>	
<b>CANADA TOTAL</b>	<b>362 436</b>	<b>139 811</b>	<b>6 623</b>	<b>229 020</b>	
% of historical range		38.58%	1.83%	63.19%	

<sup>a</sup> Habitats from state GAP analyses (USGS National GPA Analysis Program, <http://gapanalysis.nbii.gov/portal/server.pt> 2008) and Government of Canada/Agriculture and Agri-Food Canada (2008) with potential for occupation by Swift Foxes.

<sup>b</sup> High-quality grassland habitats: short to mid-height perennial grassland habitats.

<sup>c</sup> Medium-quality grassland habitats: mid-height to tall perennial grassland habitats with sparse shrub component.

<sup>d</sup> Medium-quality cropland habitats: suitable agricultural lands, predominantly with dryland cropping practices.

<sup>e</sup> Low-quality cropland habitats: cropland marginally suitable or of unknown suitability.

<sup>f</sup> Kansas GAP did not separate dryland farming practices from others. This estimate is modified based on the estimate by Rogers et al. (2000\*) of 67% dryland crops in western Kansas.

## Notes

### Diel Activity Patterns of Mink, *Neovision vison*, Change with Habitat

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Using video traps, we tested the commonly held view that Mink, *Neovision vison*, are mostly nocturnal. We compared Mink passages during daylight and darkness in two habitats. Mink were significantly more nocturnal in uplands with streams and significantly more diurnal in wetlands. Assuming that uplands have a higher proportion of terrestrial prey active at night and wetlands have a higher proportion of aquatic prey, the observed difference in activity periods may be related to the difficulty of seeing aquatic prey at night and suggests a dynamic interaction between food visibility and diel activity in Mink.

**Key Words:** Mink, *Neovision vison*, diel activity patterns, video traps, wetlands, uplands, prey, New York.

Many authors report that Mink, *Neovision vison*, are mostly nocturnal, but diurnal activity has also been reported (Gerell 1969; Melquist et al. 1981; Birks and Linn 1982; Eagle and Whitman 1987; Zielinski 1988; Niemimaa 1995). We used video traps to record day-time and night-time passages of Mink in wetlands and uplands, and we compared passage rates between the two habitats.

#### Study Area

Four video traps were placed in each of four areas north and west of Rochester, New York (map in Haynes et al. 2007\*); we classified two areas as “wetland” habitat and two as “upland/mixed” habitat. One wetland habitat was the 16 km<sup>2</sup> Braddock Bay State Wildlife Management Area, separated by narrow barrier beaches from Lake Ontario. The second wetland habitat was in the Iroquois National Wildlife Refuge and two connected state Wildlife Management Areas (77 km<sup>2</sup> total) located 50 km southwest of the Braddock Bay State Wildlife Management Area. One upland/mixed habitat (~35 km<sup>2</sup>) surrounded Black Creek and some of its tributaries near the Bergen Swamp 34 km south of the Braddock Bay State Wildlife Management Area. The second upland/mixed habitat (~15 km<sup>2</sup>) was centered 20 km west of the Braddock Bay State Wildlife Management Area, where two creeks drain into Lake Ontario.

#### Methods

The video traps were run from June 14 to October 28 in 2003 and from June 4 to October 20 in 2004. The

video traps were operated for a total of 1665 trap-nights in wetland habitat and 1190 trap-nights in upland habitat.

The “MustelaVision” video trap system was designed to work day and night and to operate quietly and invisibly, in order to avoid disturbing the animals (see Haynes et al. 2007\* for design and construction details). The system consisted of an electronic camera head (sensitive to both visible and infrared radiation) attached by a 50-foot cable to a two-head videocassette recorder powered by a 12-volt DC battery. During daylight, the camera monitored an area 3 m wide by at least 12 m deep (depending on camera angle relative to the ground). At night, the six infrared LEDs (always on) in the camera head provided a pool of illumination on the ground about 1 m wide by 2 m deep (again depending on camera angle). However, animals were detected up to at least 10 m from the camera at night due to eye shine and body heat against a cooler background. The camera head also included an infrared motion detector. When the sensor detected motion, the VCR started recording. Thirty seconds after motion ceased, the VCR stopped recording.

We placed the video traps near the edge of the water in wetlands or along streams in each area; the video traps were aimed at the edge of the water in and along which a Mink would move and sometimes at a tunnel through which the Mink would be forced to travel.

A “Mink passage” began when a Mink came into the field of view and the camera was triggered and ended 30 seconds after the Mink left, when the camera turned off. Thus, multiple passes in and out of the



field of view before the camera stopped recording were recorded as one passage. Likewise, if the camera stopped and restarted while the animal remained motionless within the field of view, that was counted as one passage. In rare cases in which multiple Mink were recorded, their number was noted for that passage.

A Mink passage was recorded as occurring during "day" when natural light illuminated the entire field of view of the camera. A passage was defined as occurring at "night" when only objects illuminated by the camera's LEDs could be seen and the area outside that pool of illumination was dark. Because we had no way to date-stamp the recordings, we recorded the beginning and end dates of each recording session (usually one week long). These dates were used in calculating the duration of daylight as described below.

We summed day and night passages separately for all sites and for wetlands and upland/mixed sites over both years to get the total observed day and night passages. Using the null hypothesis that Mink have no preference for daylight or darkness, we calculated the number of passages expected during day and night based on the duration of daylight (U. S. Naval Observatory 2007\*) during those weeks in which Mink passages were recorded. We then used a chi-square goodness-of-fit test to compare observed and expected passage numbers for day and night in each habitat to determine whether the Mink were nocturnal (more observed night passages than expected) or diurnal (more observed day passages than expected).

## Results

A total of 225 Mink passages were recorded—136 in daylight and 89 at night. Only twice did we see obvious family groups consisting of a mother with young (at separate sites, one during day and one at night), and on two other occasions we saw two Mink travelling together in daytime, again at separate sites. The rest of the observations were of single Mink.

When data from all four areas were combined, the number of Mink passages observed in day and night did not differ significantly from the numbers expected if Mink showed no preference for daylight or darkness: 60.4% of the passages were recorded during daylight; during those weeks, 56.0% of the hours were daylight ( $n = 225$ ,  $\chi^2 = 1.776$ ,  $P = 0.183$ ). However, when the data were separated into wetlands and uplands/mixed habitat, significant differences were obtained. The uplands/mixed habitat Mink were nocturnal: only 33.3% of the passages were recorded during daylight; during those weeks, 56.8% of the hours were daylight ( $n = 21$ ,  $\chi^2 = 4.724$ ,  $P = 0.030$ ). In contrast, the wetlands Mink were diurnal: 63.2% of passages occurred during the daytime; during the weeks those passages were recorded, daylight hours comprised 55.9% of the total time ( $n = 204$ ,  $\chi^2 = 4.490$ ,  $P = 0.034$ ).

## Discussion

Our results showed that although upland Mink in our study were indeed nocturnal, wetland Mink showed a significant preference for daylight. Gerell (1969) observed that the availability of prey seemed to be the biggest factor affecting diel activity of Mink. Eagle and Whitman (1987) and Dunstone (1993) reported that Mink travel along the shore while foraging, and they enter the water to take aquatic prey only after they have spotted it from a vantage point such as a rock or log. Dunstone also noted that Minks' visual acuity in water is only about half that in air; therefore, more light is needed for aquatic than terrestrial hunting. Based on these observations, it is logical that Mink relying more heavily on aquatic prey would be more diurnal than Mink feeding on terrestrial prey.

Gerell's (1969) hypothesis is supported by Melquist et al. (1981), who concluded that the higher degree of nocturnal activity in the Mink they studied was a result of the nocturnal activity of small rodents such as meadow voles (*Microtus* spp.) and deer mice (*Peromyscus* spp.), a significant portion of the diets of those Mink. Further support comes from Niemimaa's (1995) report of the activity patterns of seven Mink he radio-tracked in a sea archipelago in southwest Finland: two were diurnal, four showed no preference, and only one was nocturnal. Niemimaa concluded that these findings could be expected based on the availability of prey; during his study period in autumn and early winter, the main diet of the Mink was fish.

Although we did not study the diet of Mink, live-trapping data in our study area indicated that species richness and diversity and the abundance of the most common nocturnal small mammals in the area (Meadow Vole, *Microtus pennsylvanicus*, and White-footed Mouse, *Peromyscus leucopus*) were higher in upland habitats than in wetlands (Makarewicz et al. 2000\*). If wetlands offer a greater variety and abundance of aquatic prey than uplands, then Mink in wetlands should consume more aquatic prey than Mink in uplands. If these assumptions are correct, our study further supports Gerell's (1969) hypothesis that activity patterns of Mink are influenced by those of their prey and that those patterns vary according to the availability of prey in different habitats.

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and Historic Preservation, and the United States Fish and Wildlife Service. Many trappers in New York provided valuable advice, and Christopher J. Norment reviewed an earlier version of the manuscript.

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## Uterine Prolapse in an Adult Richardson's Ground Squirrel, *Spermophilus richardsonii*

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During a study of Richardson's Ground Squirrel (*Spermophilus richardsonii*) populations in southern Saskatchewan, we captured one adult female with a partially prolapsed uterus. This is the first known case of uterine prolapse in a Richardson's Ground Squirrel.

**Key Words:** Richardson's Ground Squirrel, *Spermophilus richardsonii*, uterine prolapse, Saskatchewan.

Uterine prolapse is a condition where the uterus falls down or slips out of place, invariably after or within several hours of parturition, when the cervix is open and the uterus lacks tone (Kahn 2009). Uterine prolapse is known to occur in farm and captive ungulates (Woodward and Quesenberry 1956; Hooper et al. 1993; Ramadan and Hafez 1993), pets (Laber-Laird et al. 1996), and laboratory rodents (Foltz and Ullman-Cullere 1999), but is poorly documented in wild animals.

During a study of Richardson's Ground Squirrel (*Spermophilus richardsonii*) populations in Ponteix (49°44'50"N, 107°29'16"W) in southern Saskatchewan, we live-captured an adult female with a partially (one uterine horn was not inverted) prolapsed uterus in May 2009. The uterus hung down between the hind legs (Figure 1). The female had well-developed nip-

ples and appeared to have lactated. We recaptured the animal four times over a 10-day period (i.e., every 2–3 days). During the first three recaptures, the animal showed no sign of illness. However, 10 days after the original capture, the uterus was bright pink and clean ventrally, but black and foul-smelling dorsally. Thereafter, we never recaptured this particular Richardson's Ground Squirrel. Because she inhabited a field that was treated with an anticoagulant toxicant, she may have died from poisoning. On the other hand, because of necrosis and infection, uterine prolapse generally has a poor prognosis (Foltz and Ullman-Cullere 1999; Kahn 2009), and the Richardson's Ground Squirrel may have died from her injuries.

There are no records of uterine prolapse in wild ground squirrel populations. Although we captured 629 female adults from 2007 to 2009, this was the only



case (0.2% rate of occurrence) observed. We do not believe that uterine prolapse is a common occurrence in Richardson's Ground Squirrel populations.

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FIGURE 1. Live-captured Richardson's Ground Squirrel with partially prolapsed uterus, southern Saskatchewan, May 2009.

## Extension of the Known Range of the Gray Treefrog, *Hyla versicolor*, in Northwestern Ontario

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Weller, Wayne F. 2009. Extension of the known range of the Gray Treefrog, *Hyla versicolor*, in northwestern Ontario. Canadian Field-Naturalist 123(4): 372–374.

I present the first documented records of Gray Treefrog, *Hyla versicolor*, from the Red Lake area of Kenora District in northwestern Ontario. A photograph of *H. versicolor* was taken at a locality west-northwest of the town of Red Lake in 2007 and another east of Red Lake in 2009. *H. versicolor* choruses were heard at 11 localities east and southeast of Red Lake in June 2008, and were tape recorded at 5. These seven documented records are 46–56 km north-northwest of the previous most northern voucher, west of the town of Ear Falls, and they represent the most northern locations known for *H. versicolor* in Ontario.

Key Words: Gray Treefrog, *Hyla versicolor*, distribution, Ontario.

It can rarely be determined with certainty whether observations of plants and wildlife at locations beyond their “known” range truly represent range extensions into previously unoccupied areas, or they represent simply the first reported observations in areas by someone knowing the significance of the sighting. True range extensions could arise due to changes in weather conditions making previously unoccupied habitats more conducive (Grayson and Bloch 2009). Climate change can interact with species-specific biological factors to influence expansion or contraction in distribution (Hellmann et al. 2008; Douglas et al. 2009; Bradley et al. 2009). Given these factors, and the fact that declines in amphibian and reptile populations have been identified worldwide, including in Canada (Green 1997; Seburn and Bishop 2007), it is important to document observations that are, or at least appear to be, extralimital records.

Here, I present noteworthy observations of Gray Treefrogs (*Hyla versicolor*) from Kenora District in northwestern Ontario. Evening surveys in June 2008 conducted by the author and opportunistic wildlife observations in September 2007 and July 2009 by others resulted in records of *H. versicolor* in the Red Lake area (Figure 1, Table 1). Specimens were photographed (see Figure 2) at 2 localities, and choruses were heard at 11 others. Habitats varied from roadsides, flooded ditches and ponds, to extensive wetlands in mainly coniferous/deciduous forested areas (Table 1). Taped recordings of *H. versicolor* choruses were made at 5 of the 11 localities. The digital images and taped recordings have been submitted to the Royal Ontario Museum (ROM), Toronto, Ontario, Canada, as vouchered records. Voucher identifications have been verified by R. D. MacCulloch.

Weller (2002) reported the occurrence of *H. versicolor* at Manitou Falls Generating Station, located at the western terminus of Highway 804 west of the town of Ear Falls. At the time, this represented the most northern record in Ontario, and it extended the documented range over 110–130 km northward from

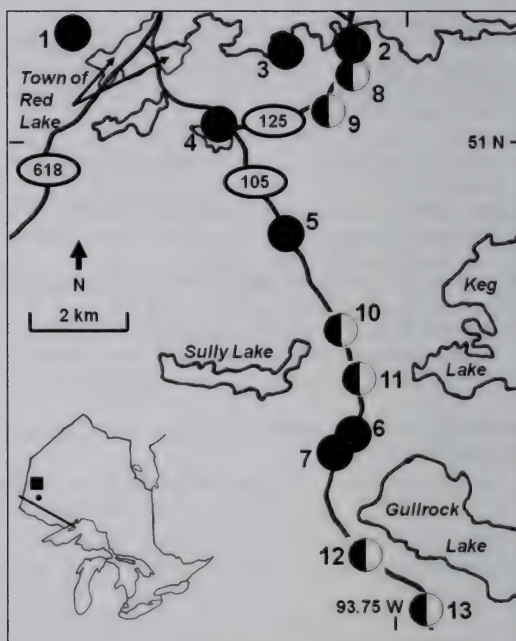


FIGURE 1. Map showing locations for Gray Treefrog, *Hyla versicolor*, in the Red Lake area of Kenora District. Solid square in inset map indicates location of survey area relative to the province of Ontario. Solid circles represent vouchered records (photographs or tape-recorded calls). Half-filled circles represent unvouchered observation records. Numbers refer to locations in Table 1. Diagonal line in inset map represents the approximate northern limit known prior to the Manitou Falls record reported in Weller (2002), and the small solid dot represents the record reported in Weller (2002) at Manitou Falls.

the Kenora–Dryden area. The seven vouchered records reported here extend the documented range of *H. versicolor* an additional 46–56 km north of the Manitou Falls record. It remains uncertain whether the range of *H. versicolor* extends farther north than the Red



TABLE 1. Records of *Hyla versicolor* in the area of Red Lake, Kenora District, Ontario, over the period 2007–2009. Compass directions are in relation to the town of Red Lake. Locations were determined with Garmin GPS using NAD83 format. NR = not recorded. CI refers to “calling index”, used in the amphibian marsh monitoring program (Bird Studies Canada 2008\*) to quantify intensity of calling. Documentation is in the form of digital photographs (e.g., ROM 46446(1), with brackets indicating tape segment number).

Location Description	GPS	Date / Time / Conditions	Habitat	Evidence	Documentation
<b>Vouchered records</b>					
1. WNW of Red Lake	51.0245°N 93.8424°W	4 September 2007 / daylight / NR	Forested, residential	1 observed	ROM dm00201
2. E of Red Lake, Hwy 125	51.0234°N 93.7654°W	16 June 2008 / 22 00 h, dark / ~15°C	Flooded roadside ditch	2 calling	ROM 46446(1)
3. E of Red Lake	51.0213°N 93.7828°W	19 July 2009 / daylight / NR	Garden, residential	1 observed (Figure 2)	ROM dm00202
4. SE of Red Lake, Hwy 105	51.0057°N 93.8001°W	16 June 2008 / 22 30 h, dark / ~15°C	Flooded roadside ditch	2 calling	ROM 46446(2)
5. SE of Red Lake, Hwy 105	50.9838°N 93.7831°W	17 June 2008 / 22 45 h, dark / ~18°C	Beaver marsh	Many calling, CI = 3	ROM 46446(5)
6. SE of Red Lake, Hwy 105	50.9489°N 93.7636°W	17 June 2008 / 22 25 h, dark / ~17°C	Small roadside pond, forest	Several calling, CI = 2	ROM 46446(4)
7. SE of Red Lake, Hwy 105	50.9480°N 93.7643°W	17 June 2008 / 22 15 h, dark / ~17°C	Beaver pond	Many calling	ROM 46446(3)
<b>Observations (unvouchered records)</b>					
8. ESE of Red Lake, Hwy 125	51.0170°N 93.7679°W	16 June 2008 / 22 20 h, dark / ~15°C	–	Several calling (CI = 2) from distant location	–
9. ESE of Red Lake, Hwy 125	51.0088°N 93.7766°W	16 June 2008 / 22 30 h, dark / ~15°C	Large wetland	3 calling from distant location	–
10. SE of Red Lake, Hwy 105	50.9697°N 93.7687°W	17 June 2008 / 22 35 h, dark / ~18°C	Forested	Many calling (CI = 3) from distant location	–
11. SE of Red Lake, Hwy 105	50.9566°N 93.7618°W	17 June 2008 / 22 30 h, dark / ~18°C	Forested	Many calling (CI = 3) from distant location	–
12. SE of Red Lake, Hwy 105	50.9235°N 93.7542°W	17 June 2008 / 22 00 h, dusk / ~18°C	Forested	Many calling (CI = 3) from distant location	–
13. SE of Red Lake, Hwy 105	50.9160°N 93.7398°W	17 June 2008 / 21 50 h, dusk / ~18°C	<i>Typha</i> marsh	Many calling (CI = 3) from distant location	–

Lake area in northwestern Ontario. Access to areas north by public road is very limited, but there is a network of private logging roads in the area. Surveying for *H. versicolor* along these roads may prove successful. I encourage naturalists and staff of conservation organizations and wildlife agencies to incorporate searches for *H. versicolor* into future wildlife surveys in the Red Lake area, and to document the results.

### Acknowledgments

I thank L. Austen and P. Dittrich for providing photographs of *H. versicolor* found on their properties and for permission to include their information in this note. Special appreciation is extended to N. Dawson, and especially to L. Skitt for informing me of the additional information that has been included in this paper. My thanks are extended to R. D. MacCulloch for verifying the identification of the photographs and tape-recorded choruses. I thank the anonymous reviewers for their helpful comments.

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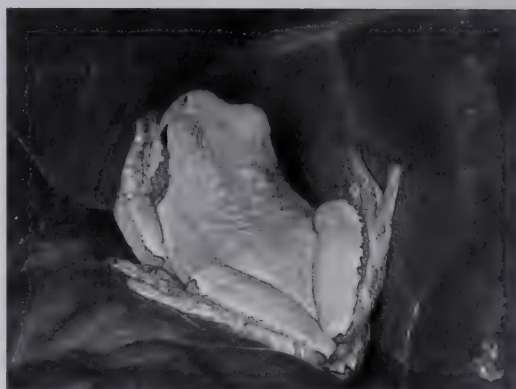


FIGURE 2. Adult Gray Treefrog (*Hyla versicolor*) nestled in the fold of a rhubarb leaf in a rural garden east of the town of Red Lake, Ontario, on 19 July 2009. (Photo by P. Dittrich).

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# New Distribution Records for Painted Turtles, *Chrysemys picta*, from Northwestern and Northeastern Ontario

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Weller, Wayne F. 2009. New distribution records for Painted Turtles, *Chrysemys picta*, from northwestern and northeastern Ontario. *Canadian Field-Naturalist* 123(4): 375–376.

Records of Western Painted Turtle (*Chrysemys picta bellii*) in northwestern Ontario and of Midland Painted Turtle (*C. p. marginata*) in northeastern Ontario extend the documented range northward. Two records of *C. p. marginata* represent the first records for the Timiskaming District.

Key Words: Western Painted Turtle, *Chrysemys picta bellii*, Midland Painted Turtle, *C. p. marginata*, distribution, Ontario.

Fieldwork in June 2008 in northwestern Ontario and in May 2008 and June 2010 in northeastern Ontario yielded new distribution records for Painted Turtles (*Chrysemys picta*); these records represent localities beyond the known northern documented range (Oldham and Weller 2000\*). Localities were recorded with a Garmin GPS in NAD83 format, and are presented in Figure 1 in a north to south order. Digital photographs were taken and deposited as vouchered records in the herpetological collection of the Royal Ontario Museum (ROM), Toronto, Ontario. The identification of photographs was verified by Ross D. MacCulloch. Nomenclature follows the Society for Study of Amphibians and Reptiles Committee on Standard English and Scientific Names (Crother 2008).

## *Chrysemys picta bellii* (Western Painted Turtle)

ONTARIO: KENORA DISTRICT, north of Stone River on Highway 105, 14.7 km south-southeast of the town of Red Lake (50.89873°N, 93.73395°W). 17 June 2008. W. F. Weller. ROM photographic voucher 46449. Adult female found crossing asphalt road at 1655 h. KENORA DISTRICT, Ear Falls Township, Caribou Creek, 29.6 km southeast of the town of Red Lake (50.86359°N, 93.48141°W). 16 June 2008. W. F. Weller. ROM (photographic voucher) 46448. Adult observed basking on a floating log in creek at 1450 h.

Documented records of *C. p. bellii* in Kenora District west of Dryden are represented by six localities (Figure 1; left side, north to south, open circles): Domain Lake, Woodland Caribou Provincial Park – September 1985, Canadian Museum of Nature (CMNAR) 28089; Highway 525, 9 km north of Wabaseemoong First Nation community – May 1994, ROM (photographic voucher) 46447; town of Malachi, ROM 9411; ca. 3 km northwest of town of Keewatin – August 1963, CMNAR 7340; Twin Lake, Highway 17, west of the town of Kenora – June 1983, CMNAR 24652; and Blindfold Lake, ca. 15 km southeast of Kenora – July 1976, CMNAR 18568.

ROM 46448 and 46449 represent the most northern documented records east of 94°W longitude in Ontario and the first for the Red Lake area, contrary to the Ontario Herpetofaunal Atlas (Oldham and Weller

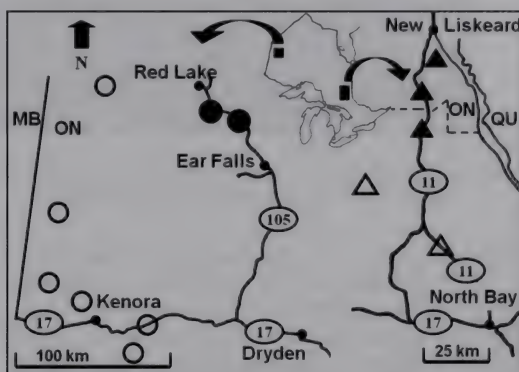


FIGURE 1. Map showing localities for *Chrysemys picta bellii* in northwestern Ontario (circles) and for *C. p. marginata* in northeastern Ontario (triangles). Solid symbols represent documented records reported in this paper, and open symbols, previous documented records. Details of localities provided in text. Dotted line in northeastern Ontario section (New Liskeard to North Bay) of map represents the approximate boundary between Timiskaming District (north) and Nipissing District (south). MB = Manitoba; ON = Ontario; QU = Québec.

2000\*). They are ca. 62 km more easterly than the Domain Lake record and ca. 123 km more northerly than the Twin Lake record. With additional fieldwork, it is certain that *C. p. bellii* will be documented at more northern locations than presented here. Periodic observations have been made over 15 years (1993–2008) in the Red Lake area and north along the Nungesser Road (Oldham and Weller 2000\*; N. Dawson, personal communication).

## *Chrysemys picta marginata* (Midland Painted Turtle)

ONTARIO: TIMISKAMING DISTRICT, Coleman Township Municipality, 2.2 km south-southeast of the town of Cobalt Post Office (47.37814°N, 79.67000°W). 17 June 2010. W. F. Weller. ROM (photographic voucher) dm00269. One adult observed basking at 1230 h on a log at the western shoreline of an unnamed mine tailings pond. TIMISKAMING DISTRICT, Gillies, 7.5 km



FIGURE 2. Basking Midland Painted Turtle, unnamed pond 2.2 km south-southeast of Cobalt, 17 June 2010. W. F. Weller (Royal Ontario Museum, photographic voucher, dm00269).

southeast of the town of Latchford (47.26811°N, 79.77426°W). 29 May 2008. W. F. Weller. ROM (photographic voucher) 46450. Five adults observed basking on grassy shoreline of a small lake at 0910 h. NIPISSING DISTRICT, Strathy Township, 1.3 km north of the town of Temagami (47.07832°N, 79.79232°W). 29 May 2008. W. F. Weller. ROM (photographic voucher) 46451. Three adults observed basking on two logs in pond at 1005 h.

Documented records of *C. p. marginata* in northeastern Ontario are represented by only two localities in Nipissing District (Figure 1; right side, north to south, open triangles): Lake Temagami – July 1930, ROM 2345-46; and 5.1 km north of Tomiko on Highway 11 – June 1983, CMNAR 24562.

ROM 46451 represents the most northern documented record in Nipissing District. ROM 46450 and ROM dm00269 represent the first documented records in Timiskaming District. Located ca. 58 km north of the Lake Temagami record, ROM dm00269 is the most northern documented record in northeastern Ontario. With future surveys, additional observations of *C. p. marginata* are likely to be made in more northern areas of Timiskaming District since, to the east in Québec, Painted Turtles occur north of 48°N (Bider and Matte 1996; Desroches and Rodrigue 2004).

Records of both Painted Turtle subspecies reported here extend the known ranges northward from those limits reported in Bleakney (1958), Schueler (1976), and Conant and Collins (1998).

### Acknowledgments

I thank N. Dawson for providing information on observations of *C. p. bellii* in the Red Lake area and R. D. MacCulloch for verifying the identification of the

photographs and providing comments on an earlier draft. I thank F. W. Schueler and an anonymous reviewer for valuable comments that helped to improve this paper.

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# Book Reviews

**Book-review Editor's Note:** We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars are AUD and so on.

## ZOOLOGY

### **The North American Porcupine (Second edition)**

By Uldis Roze. 2009. Cornell University Press, Ithaca and London. 282 pages, 35 USD Cloth.

*The North American Porcupine*, second edition, is a beautiful book. Written by Uldis Roze, professor emeritus of biology at Queens College, City University of New York, and porcupine researcher extraordinaire, it provides highly readable and informative insight into the biology and life history of a highly underappreciated and often misunderstood (and persecuted) denizen of North American forests. This is a must-read for any naturalist seeking to develop a deeper understanding of our native wildlife.

The book is divided into 14 chapters that discuss a comprehensive range of topics: porcupine anatomy, defence reaction (those formidable quills and how they work), and parasites; the animal's salt drive, and seasonal foraging and denning habits; its social structure, reproduction, and maternal care; members of the greater global porcupine family; porcupine-human relations; and two chapters focusing on individual porcupines, Musa and Squirrel, the author had the pleasure to study in depth. A detailed references section and index, along with colour and black-and-white photographs, accompany the text.

The content of the book is based on the author's long-term telemetry study of porcupines in the Catskill Mountains. Over the course of more than 25 years, Roze followed porcupines through the woods at all hours of the day and night, observing their behaviour and environment and capturing them to conduct physical examinations. He also conducted laboratory analyses to solve puzzles, and he nursed individual porcupines back to health (at his home in New York City!) when they were ill.

It is his personal touch, his intimate involvement with his research subjects, his obvious appreciation and respect for the individual animal, that make this book a true gem and make Roze a particularly credible and sympathetic author. In the preface to the second edition, for example, he writes that his later studies revealed the length and complexity of porcupine life, reinforcing his decision not to conduct experimentation that would harm the animals—a decision he has not regretted. He adds, at the end of the "Porcupines and People" chapter, that the porcupine has repeatedly

played the role of "a teacher, a storyteller of the woods, a complexifier and adorer of the world" (page 14).

Roze's many porcupine teachers appear in the descriptive and lyrical pieces that open each new chapter and in the personal stories woven throughout the book. Things he learned from porcupines include the way in which they cope with the toxicity of the tree leaves and bark they eat: porcupines ingest clay, which detoxifies plant tissues by binding with their tannins and alkaloids. Roze also learned, from the porcupines he followed, about their strategy for assembling the intestinal flora necessary to digest the complex polymers present in the changing pattern of plants available in new locations: the animals eat parts of droppings left by previous porcupine inhabitants.

By far the most intimate and engaging parts of the book are the last two chapters: "Travels with Musa" and "The Oldest Porcupine." The first traces a five-month adventure literally walking with Musa, an orphaned baby porcupine Roze adopted, nurtured, and raised—in full recognition of what he expresses as his responsibility for the emotional and intellectual development of a sensitive and intelligent animal—for ultimate release back into the wild. Along the way, through wanderings and occasional misadventures, Musa provides teachings about porcupines that more traditional studies could not reveal, a process Roze compares to friendship, "the slow opening of inner secrets that add dimension and empathy to a life not one's own" (page 237).

In "The Oldest Porcupine," Roze portrays the other end of porcupine life, old age, with the spotlight on Squirrel, a porcupine he followed for over 20 years as she navigated through young adulthood, fruitful motherhood, menopause, and old age. As the world's oldest monitored porcupine in the wild, Squirrel has scientific importance. As an animal Roze watched, followed, and admired for decades, she has personal significance, altering his perception of the landscape through memories associated with her presence in particular places. "I will always see the forest differently" he writes (page 258)—because of Squirrel.

*The North American Porcupine*, second edition, is a comprehensive and compelling book, a tribute to a mysterious and often unloved wildlife species written by a man who studied the animals intimately for decades. It is both a valuable source of scientific information about porcupines and an eloquent appeal to respect and appreciate these animals for their uniqueness, adaptability, and ability to astonish. Time and time again, Roze writes, the porcupine has forced him to

"take another look at the forest, its natural home, from a different perspective" (page 14).

This book has forced me to look at porcupines from many different perspectives—I will never look at the animal or its traces the same way—and for that, it has gained a prominent place on my bookshelf.

RENATE SANDER-REGIER

3, 11th Line, Bristol, Quebec, Canada

## **Amphibian Biology Volume 8: Amphibian Decline: Diseases, Parasites, Maladies and Pollution**

Edited by Harold Heatwole and John W. Wilkinson. 2009. Surry Beatty & Sons Baulkham Hills, Australia. xiii + 338 pages.

This series began in 1994, inspired by the classic multi-volume *Biology of the Reptilia* series begun in 1969 by Karl Gans. The amphibian equivalent was initiated by its senior editor Harold Heatwole. There have been seven previous Amphibia volumes in this series covering Integument, Social Behaviour, Sensory Perception, Palaeontology, Osteology, Endocrinology, and Systematics. The pages in the series are numbered consecutively from volume one. This volume is pages 2963 to 3290.

The new volume tackles the highly publicized causes implicated in a worldwide amphibian decline. There are 12 chapters produced by an international group of 29 authors, 14 are the United States. The remainder are 6 from Australia, 3 from Spain, and 1 each from Canada, Italy, Nigeria, Puerto Rico, Switzerland, and the United Kingdom. The problem of the rapid changes in nomenclature as promoted by Frost et al. (2006 American Museum of Natural History Bulletin 297) is solved by letting authors of each chapter adopt the new nomenclature or use the old.

The introduction flatly states that basic to the problem of apparent declining biodiversity is the ever-expanding human population. This now exceeds the carrying capacity of the earth. Its maintenance at present levels is sustained by fossil reservoirs of energy, soil, water, and even oxygen. As these continue to be depleted the obvious conclusion is that the long-term future is bleak for our own species, and perhaps for all life. But that is far ahead and here the focus is on present and immediate declines and extinctions of many frog species and some of the major contributing factors.

The book is dedicated to Lee Burger, who co-authored the volume's two initial papers. In 1998, Dr. Berger published the discovery of *Batrachochytrium dendrobatidis*, causing chytridiomycosis, an infection of the skin of frogs. Subsequent work has implicated it in mass mortalities and documented its spread worldwide. A map on page 2988 gives its world distribution. North America and Australia both have continent-wide incidence of reports, but no continent has completely escaped its presence.

Initially the book concentrates on this and other infections and then moves to the variety of other causes of declines. The first three chapters focus on: viral, bacterial, and fungal outbreaks and interspecific variation in susceptibility. Chapter 4 is on digenetic trematodes and 5 on the incidence of malformations and the ongoing debate on their major causes. Chapter 6 is on ultraviolet-B radiation. Chapter 7 covers nitrogen pollution, 8 impact of pesticides, 9 endocrine disrupting chemicals, 10 petrochemicals and heavy metals, 11 acidification and 12 climatic change. The only Canadian contributor, David Green of McGill, coauthored Chapter 11.

The result of the documenting and synthesis of many approaches is somewhat inconclusive. At some localities some species have been directly and heavily impacted. Species have disappeared from known causes but others are still speculative. We still lack conclusive evidence for one single causative factor worldwide or a single strategy to reverse the widespread trend of amphibian decline. This despite massive concentration of recent and continuing research on the problem.

Future volumes for *Amphibian Biology* are already planned. These will be on (1) the roles of anthropogenic influences such as habitat change; introduction of alien species; roadkills; direct harvesting, trade, and the use of amphibian species by humans, (2) various ecological, phylogenetic, and geographic correlates of amphibian decline, (3) monitoring programmes and concentration practices such as the establishment of refugia, captive breeding and re-introduction; and mitigation; as well as the application of education. The last volumes will assess the global status of conservation and decline on a region-by-region basis to serve as a bench marks for subsequent changes that take place.

Concerned naturalists will seek the current volume out in libraries to widen their appreciation of just how complicated the interactions between the various studied factors are. Researchers will value it as a reference to what has been accomplished so far.

FRANCIS R. COOK

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## Frogs: Inside Their Remarkable World

By Ellin Beltz. 2005. Firefly Books, Richmond Hill, Ontario. 175 pages.

The spectacular feature of this book is its over 160 vivid colour frog portraits and two coloured diagrams of skeletal and internal structures of a typical frog from a variety of sources which effectively depict the range of frog diversity. But it is not just another pretty picture book. The text, though brief, is both instructive and entertaining on a wide range of frog topics. It is a near perfect introduction to a world overview of these lively and attractive animals for anyone young or old.

Two opening pages are acknowledgments in which the author confesses her obsession with frogs since childhood and thanks the people who have influenced and helped her through her life thus far. The book is dedicated to one of these, the late herpetologist Angus Bellairs. His remarkable ability share his knowledge was observed by Beltz to hold the attention of listeners from school children to aging veteran herpetologists.

A three-page introductory text tantalizes the reader to read further with contrasts such as one toad observed to eat over one thousand food items in a day with some frogs in hot deserts that can go six months or more without eating. Twelve pages cover natural history starting with the Egyptian use of a frog profile to represent the number 100 000 and the Roman coinage of rana from the call of their local pond frogs. Subsections cover Life Before Amphibians which included simplified geological time scale table and a map of the super-continent Pangaea, prior to its break-up. A major portion, 50 pages, is the section on frog diversity in a traditional classification of families [publication was before the massive overhaul of classification and the breakup of many genera by Frost et al. (2006 American Museum of Natural History Bulletin 197)]. This is followed by 35 pages on anatomy and physiology, 26 on environment adaptation, 24 on frogs in

myth and culture. In the latter it is noted that "Considering their amazing choruses, breeding, groups, huge numbers, of eggs and offspring, it is easy to see how early peoples would make the connection of frogs with fertility".

The book concludes with a 4-page epilog, 8 pages of frog miscellany: largest frog is *Conrana golith* of Africa which can weigh up to 8 pounds (3.6 kg) and grow to 35 inches (89 cm) long, the smallest are the Gold Frog, *Psyllophryne didactyla* in the southern hemisphere and *Eleutherodactylus iberia* of the northern, each measuring  $\frac{3}{8}$  inch (9.5 mm). Concluding the book are a 6-page glossary, a surprisingly brief 2 pages for references (although British Columbia's Harry Parsons' *Frogs with Attitude* is one of the few that are included), 3 pages of photo credits and a nine page index.

In an Epilog, Beltz is upbeat on the future for frogs, in contrast to the many recent publications which stress their decline. Her view is matter-of-fact acceptance. "All may be lost for some frogs, but other frogs are – as they have been for millions of years – on the move and expanding their range." And on dynamics and change: "Nature is unbalanced. Nature is random ... events are rarely, if ever, predictable. That is why Nature is described as 'stochastic' – random events happening randomly, producing what can be made to appear like an ordered structure". She speculates that as frogs which expand their ranges subsequently "become isolated in new habitats, speciation may occur. Or the frogs may be wiped out in stochastic events. It is Nature. One never knows".

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## Natural History of West Indian Reptiles and Amphibians

By Robert W. Henderson and Robert Powell. 2009. University of Florida Press, Gainesville, Florida. xiv + 495 pages.

The West Indies has long been as attractive to herpetologists as it is to sun-seeking tourists. Colonization of, and evolution on, the over 600 islands comprising the Greater and Lesser Antilles that lie between Florida and South America, have produced a researchers' paradise. The various degrees of separation between islands and their diverse topographies have combined to influence the evolution of a multitude of forms. This has long drawn taxonomists and ecologists alike to study their relationships and division of habitats.

This book is neither a coffee-table presentation nor a field guide for tourists. The colour cover depicts a patternless reddish-brown snake, *Magliophis exiguous*, family Dipsadidae, of Puerto Rico and Virgin Islands.

Three other species, two lizards and a frog have colour cameos, one on the spine and the others on the back cover. But inside, it is all black-and-white, with only 34 photographs, each depicting a single representative of each included family.

The text begins with two maps, one of the entire Antilles and a companion map of the Lesser Antilles on a larger scale. A 22-page introduction follows which lays out the content and organization of the book. Figure 2 on page 4 emphasizes the growth of herpetological studies for the islands. It charts the total papers published which included natural history data on amphibians and traditional reptiles (excluding birds) varied from one in the 1740s to 50 in the 1930s. Due

the second World War research production dropped in the 1940s to 27 papers but publication rebounded in the 1950s with 62 papers. This marked the initiation of the intensive studies of anolis lizards by Ernst Williams and his students and of the total herpetofauna by Albert Schwartz. Thereafter, the increase has been steady with every succeeding decade and reached 697 in the 2000s.

The major portion of the book, 385 pages, presents individual accounts for 197 species of frogs and 539 reptiles (364 lizards, 17 amphisbaenians, 145 snakes, 8 turtles, and 3 crocodilians). These represent 8 families of frogs, 11 of lizards, 2 of amphisbaenids, 8 of snakes, 3 of turtles and 2 of crocodilians. Most West Indian species are unique, 99% of the frogs and 93% of the reptiles are endemic. Included in the totals are both the native and established (reproducing) introduced species. Omitted are introduced species which have not sustained an initial presence and those only recorded once which are presumed to be incidental waifs. These accounts completely omit traditional description and identification discussions to concentrate

on tight summaries of published natural history. Major topics are covered under boldface headings for easy finding. These include distribution and habitat, and often abundance, activity, behavior, reproduction, parasites, size and conservation status. These accounts are backed up by an 80-page Literature Cited section containing over 2600 references from which information was extracted.

Both serious naturalists and researchers living in, or visiting, the West Indies will find this encyclopaedic natural history an indispensable reference to the published research. The more casual or anyone needing descriptions for identification will still have to depend on the 1991 *Amphibians and Reptiles of the West Indies: Descriptions, Distributions and Natural History* by Albert Schwartz and Robert W. Henderson (University of Florida Press, Gainesville) or wait for the field guide in preparation by Blair Hedges.

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## The Rise of Amphibians: 365 Million Years of Evolution

By Robert Carroll. 2009. John Hopkins University Press, Baltimore, Maryland USA. xii + 360 pages.

The big event in our past prehistory was the challenge met by early aquatic fish-like vertebrates of colonizing the land, already populated by tempting and doubtless abundant invertebrate prey. A bonus to be gained was an escape from the increasingly crowded conditions in the adjoining water. But the later evolved often spectacularly sized dinosaurs have gained the largest share of public interest particularly from younger audiences. Since the extinction and replacement of the once-dominant larger amphibians, the group has survived, still surprisingly diverse and numerous as much smaller forms. Here, however, we are taken back to their initial ancestral appearance and long dominance.

Robert Carroll has long been synonymous with vertebrate evolution studies at Redpath Museum, McGill University. He came with an impeccable background as a Ph.D. graduate from Harvard University, a student of the legendary icon in palaeontology, Alfred Sherwood Romer. During his tenure he has, in turn, mentored a stream of diverse PhD graduate students. Some of these have come to the Canadian Museum of Nature for various periods, notably Michael Caldwell (origins of snakes) Robert Holms (dinosaurs), and Alison Murray (fish), all moving later to fossil-rich Alberta, and Xiao-chun Wu (crocodilians) who has stayed.

This book fills a long-standing gap in texts. In 16 chapters it covers the first tentative emergence to the land. It follows amphibian diversification and dominance to a mass extinction 250 million years ago. It then covers the eventual vertebrate recovery and the

amphibian replacements that evolved from the surviving stock. It concludes with the success of modern amphibians followed by speculation on the future of amphibians contributed by Carroll's successor as Director of Redpath Museum, modern herpetologist David Green. The ex-COSEWIC chair who, though admitting that there are current declines and even disappearance of some species, emphasizes that the group has survived many environmental past disasters and rebounded. It may even do better through the current human-induced one than us humans ourselves.

Fossil history is detailed by over 200 black-and-white illustrations of fossil skeletons of forms a often given only cursory coverage in many popular evolution texts in their haste to get to the time of the dinosaurs. A spectacular special color section is inserted between chapters 6 and 7. It contains 16 plates illustrating conceptions of the major extinct forms and concludes with examples from surviving groups: frogs, salamanders and caecilians.

Anyone interested in the early prehistory of vertebrates (and that should be all of us) should read this book. Its emphasis on the oft-neglected steps on the evolutionary ladder between fish and fish-like groups and the succeeding later vertebrates bring a treasure of detail largely long buried in obscure (to the majority of naturalists) scientific journals. We would not be here today without the benefits of the amphibian ancestral contribution.

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## Snakes: Ecology and Conservation

Edited by Stephen J. Mullin and Richard A. Seigel. 2009. Comstock Publishing Associates, Cornell University Press, Ithaca, New York. xiv + 365 pages. 60.00 USD.

Rumours abound that snake researchers suffer from "lizard envy" because of the successful promotion of lizards as the new model research vertebrate in recent decades. To counter this impression, here is the fourth data-rich synthesis of snake research co-edited by Richard A. Seigel in the past 23 years. It joins three impressive predecessors: *Snakes: Evolutionary Biology* (1987, co-edited with J. T. Collins and S. S. Novak), *Snakes: Ecology and Behavior* (1993, co-edited with J. T. Collins), and *The Garter Snakes: Evolution and Ecology* (1996, co-edited with D. E. Rossman and N. B. Ford). Why, then, yet another volume so soon after these benchmarks? The answer is simple, as, like other "reptiles" (in the traditional sense) and amphibians, the latter part of the 20<sup>th</sup> and early 21<sup>st</sup> centuries has seen an expanding explosion of detailed research on these groups, quickly making earlier volumes outdated. No longer are snakes largely ignored in response to the oft-quoted 1758 Christian biblical inspired dismissal by Linnaeus of all reptiles as merely "foul and loathsome". After years of inadequate study, increasing awareness and concern about the newest age of massive extinction brought on by ever-expanding human populations has brought attention even to snakes as indicators of our accelerated loss of biological diversity. This new volume is timely with its focus on conservation and habitat management to promote snake survival.

The book brings together the synthesis of current research by 24 contributors in 11 chapters preceded by an introduction by editors Mullin and Seigel "Opening the doors for snake conservation" and concluded with a chapter "Snake conservation, present and future". Between are chapters emphasizing the literature on innovative methods for studies of snake ecology and conservation. These include: molecular phylogeography; modeling snake distribution and habitat; linking behavioral ecology to conservation objectives; reproductive biology, population viability and options for field management; conservation strategies: captive rearing, Translocation, and repatriation; snakes as indicators and monitors of ecosystem properties; combating ophiophobia: origins, treatment, education, and conservation tools.

In addition, there are three chapters which include studies particularly relevant to Canadian naturalists and researchers. Patrick J. Weatherhead has joined with Thomas Madsen of Australia to author a chapter linking behavioural ecology to conservation objectives. Weatherhead was a pioneer in Canadian snake ecology. An ornithologist at Carleton University in Ottawa, conducted long-term field studies at the Queen's Biological Station north of Kingston and, early in these, became interested in the impact on bird populations by rat snakes (formerly *Elaphe obsoleta*, now best designated *Pantherophis spiloides* × *alle-*

*ghaniensis*) [see H. L. Gibbs, S. J. Corey, G. Blouin-Demers, K. A. Prior, and P. J. Weatherhead. 2006. Hybridization between mtDNA-defined phylogeographic lineages of Black Ratsnakes (*Pantherophis* sp.). *Molecular Ecology* 15: 3755-3767] and supervised theses by a number of graduate students on this species and on *Nerodia* and *Thamnophis* at the Queen's Biological Station and the Eastern Massasauga, *Sistrurus catenatus*, at Bruce Peninsula National Park. He subsequently moved to the University of Illinois. This work has lead to a solid case for the separate designation of the two Ontario rat snake populations by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) as endangered (Carolinian population in southern Ontario [*Pantherophis spiloides*] and threatened (the Great Lakes/St. Lawrence population, which includes the snakes on the Queen's University Field Station). Kent A. Prior, a former graduate student of Weatherhead's, now a critical habitat specialist with Parks Canada, has written, with New York based Americans, Kevin T. Shoemaker and Glenn Johnson, on habitat manipulation as a viable conservation strategy. Richard A. King of Northern Illinois University, has spent a career in comparative studies of the herpetofaunas of the islands shared between Ontario and Ohio at the western end of Lake Erie including Pelee and Middle islands in Canada. Although King's own research has had particular emphasis on the islands' endemic water snake subspecies, *Nerodia sipedon insularum*, his chapter on population and conservation genetics includes discussion of a broad number species, habitats, and varying selection pressures from a many studies elsewhere.

A disappointment with the book is its lack of authored contributions some other leading Canadian snake researchers. These include Gabriel Blouin-Demers, a former graduate student of Weatherhead's now at Ottawa University who has carried on the rat snake and other research at the Queen's University Biological Field Station, and Patrick Gregory and his students at University of Victoria who have studied western snakes for more than three decades, although numerous papers of both groups are cited.

Make no mistake, clearly this book is pitched at the reference level for students and established researchers. But this does not mean that the interested naturalist would not gain much from its perspective of the current and future problems in assuring some snakes survive. Its comprehensive literature that pools the citations for all chapters is an impressive section in itself at 65 pages. Also useful are the two concluding indexes, a 5-page one to scientific and common names and a 4-page subject index

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## BOTANY

**The Metamorphosis of Plants**

By Johann Wolfgang von Goethe. Photographs and Introduction by Gordon L. Miller. 2009. The MIT Press, Five Cambridge Centre, 4th Floor, Cambridge, Massachusetts. 123 pages, 21.05 USD Cloth.

Plant morphologists have long been interested in the phenotypic appearance of plant forms. They are concerned with the external structures or forms of plants, especially the various growth forms that plants take, and how such morphologies contribute to the success of each species. Early in ancient times, human beings began to be interested in the phenomena of repetitive growth of plant shoots, both in vegetative and reproductive ways. The idea of the shoot as a plant unit had been recognized since the early days of botany, but until the 17th century, not many advances had been made on the botanical principles discovered by Theophrastus.

From the writings of Goethe, the idea of metamorphosis of plants, along with much other nature philosophy, was effectively promulgated. *The Metamorphosis of Plants* (1790) was Goethe's first major attempt to describe what he called "the truth about the *how* of the organism." Inspired by the diversity of flora, Goethe sought a unity of form in diverse structures. With this short but influential book, Goethe aimed to tell the story of botanical forms in process, to present in effect a motion picture of the metamorphosis of plants. Goethe essentially discovered the (serially) homologous nature of leaf organs in plants, from cotyledons, to photosynthetic leaves, to the petals of a flower. Goethe had arrived at a sophisticated view of homology and transformation within an idealist morphological perspective, which led to the definition of "homology" given by Richard Owen and Charles Darwin later. Goethe firstly stated that the lateral branches that spring from the nodes of plants may be regarded as individual plantlets, which take their stand upon the body of the mother, just as the latter is fixed in the earth.

Goethe's book is concerned with the metamorphosis of an ideal conceptual or abstract unit of plant structure into various actual physical expressions. Such a conception was to prove extremely fruitful, and homology has lain at the core of plant morphology ever since. His treatment of the leaf as an irreducible unit, to which certain other plant structures might be homologized, has long remained influential. The search for idealized plant parts seemed naturally to predicate some basic unit or other of which higher plants might be constructed.

Typological thinking is nowadays less evident in plant morphology, although it is by no means obsolete. Readers nowadays might be very astonished at the

detailed and painstaking observational work, together with the overall vision of the idea of metamorphosis established by Goethe, which biology today recognizes as the truth of the plant. Stimulated by the thoughts of Goethe, later plant ecologists used the shapes and sizes of plants under the general rubric of physiognomy of plants or the life-forms and growth-forms, which creatively classified plants into biological groups based on the nature and organization or architecture of the shoot system, as an alternative to the species-genus-family scientific classification. An enormous amount of research in the field of vegetation analysis was also stimulated, based on plant morphological analysis.

*The Metamorphosis of Plants* was originally published in 1790, and it was reprinted many times in various editions from then on. This edition by MIT Press (photographs and introduction by Gordon L. Miller) illustrates Goethe's text with a series of surprisingly beautiful color photographs as well as numerous line drawings. It is the most completely and colorfully illustrated edition of Goethe's book ever published. It vividly shows Goethe's ideas of transformation and the interdependence of plant parts. Furthermore, this edition realizes Goethe's possible hope of providing pictures of all the plants to which he referred situated in the text, so that readers can see for themselves the specific points to which he was drawing their attention. All the previous publications of the book looked like only a skeleton, but this edition is indeed full of flesh and blood. Gordon Miller's wonderful photography and careful selection of images as well as his perceptive introduction greatly help readers easily understand the extraordinary nature of Goethe's achievement.

We can predict that this edition will further promote the popularity of Goethe's work. For those who have not yet read it, this edition will arouse their strong interest, and those who have read it will be interested in reading it again.

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## Sedges of Indiana and the Adjacent States: The Non-Carex Species

By Paul E. Rothrock. 2009. Indiana Academy of Science, 140 North Senate Avenue, Indianapolis, Indiana 46204-2207 USA. xiv + 270 pages, 45 USD.

This book provides an authoritative treatment of the identification, distribution, and ecology of the 88 species in the genera *Bolboschoenus*, *Bulbostylis*, *Cladium*, *Cyperus*, *Dulichium*, *Eleocharis*, *Eriophorum*, *Fimbristylis*, *Fuirena*, *Kyllinga*, *Lipocarpa*, *Rhynchospora*, *Schoenoplectus*, *Scirpus*, and *Scleria* that are found in Indiana. In addition to the species that are known to occur in the state, several taxa found in adjacent states (Illinois, Kentucky, Ohio, Michigan) but not yet found in Indiana, including members of the additional genera *Isolepis*, *Scirpoides*, and *Trichophorum*, have been included in the keys and species treatments.

The book begins with a foreword and a preface, the latter of which, although brief, provides an interesting personal insight into how the author began his now 35-year fascination with sedges. The main body of the book begins with an introductory chapter describing sedges in general as well as the natural regions of Indiana. The second chapter focuses on sedge morphology, including a comparative table of the three major graminoid families, Cyperaceae, Juncaceae, and Poaceae, and is complemented by several colour photographs. This chapter is followed by a brief chapter dealing with the basics of nomenclature and a summary of the 12 most common non-*Carex* sedges in Indiana, with some explanatory notes about the species (these 12 species are provided with their own key in an appendix, intended to assist sedge newcomers by enabling them to learn the common species first).

The nomenclature section is very brief, but it does cover the most important concepts and it is supplemented by appendices that relate the names used in older treatments, such as C. C. Deam's *Flora of Indiana* (1940) to those found in the more modern treatments in the *Flora of North America North of Mexico. Volume 23. Magnoliophyta: Commelinidae (in part): Cyperaceae* (2002). I have a bit more difficulty with the section on the 12 most common species, and in particular, the approach to providing a key for them. This approach implies that the novice will know that s/he has one of these 12 species. However, it is quite possible that a species other than one of these 12 will be quite abundant at a particular place, and the user could make the understandable assumption that it must be one of the 12 most common species in the book. It is perfectly justifiable to include a discussion of the 12 most common species, but the inclusion of the key could be misleading, especially for beginners who may not think of checking other possibilities.

The next chapter discusses the habitats and distribution patterns of the non-*Carex* sedges in the state and introduces the reader to tools such as coefficients of conservatism and wetness categories that provide

estimates of the breadth of habitat tolerances and moisture regime preferences. This chapter provides the basis for the way in which habitat preferences are described in the species treatments later in the book.

A summary of the relationships between sedges and humans is provided in the next chapter. Several species of sedges are, or were, economically important in various parts of the world. For example, *Cyperus papyrus* provided the original source of paper for the ancient Egyptians, as well as being a source of material for weaving mats, making canvas for sails, etc. Several species of sedges are used for ornamental, landscaping, and ecological restoration purposes, others are used for food or drink, some serve as important food items for wildlife, and some species, such as yellow nut-sedge, *Cyperus esculentus*, are considered to be among the worst weeds in the world.

A chapter on the biology of sedges provides more detail on nutrient uptake, mycorrhizal relationships, adaptation to wet soils, photosynthetic adaptations, dispersal, and germination ecology. Each of these topics is dealt with briefly, but a good overview is provided that should pique the interest of the reader. This chapter also includes some of the relatively recent ideas on the evolutionary relationships of the genera of sedges relative to other monocots and to each other, although this area of research is in a state of flux, with molecular studies frequently providing new insights.

The main body of this book is composed of the keys and species treatments. There is a key to the genera occurring in Indiana and nearby states, as well as keys to the species in each genus. Since achenes provide important distinguishing characters among genera and species, a set of excellent illustrations of achenes follows the generic key. Sets of illustrations of the achenes of the species of *Eleocharis* (spike-rushes), *Rhynchospora* (beak-rushes), and *Scleria* (nut-rushes) follow this. It probably would have been more sensible to place the illustrations of the achenes of species within individual genera in the appropriate location within the text where these genera are discussed, but perhaps the placement of all line drawings together in a group was done for formatting purposes.

Each species treatment follows a consistent format, which is explained at the beginning of the section on species accounts. The format is user-friendly, and it contains scientific and common names, synonyms, a description of the important identification features, a description of habitat preferences, including likely associated species (not restricted to sedges), a county range map as well as a general map of occurrence and status in adjacent states, and often, photographs of

habit, details of the inflorescence and/or achenes, a statement on the status of the species in Indiana, and any other remarks that the author felt were helpful in identifying or in understanding the distribution or ecology of the species in the state. In general, I found the information provided in the species treatments to be relevant and interesting.

Most aspects of the production, content, and appearance of this book are attractive, informative, and accessible to the non-expert and expert alike. The author's writing style is entertaining at times, in addition to being authoritative. The most disconcerting aspect of the book is the relatively frequent occurrence of grammatical errors, reflecting poor copy editing. Nevertheless, overall, this book provides a very good summary of the state of knowledge of the identification, distribution,

status, and ecology of the non-*Carex* sedges of Indiana, and I recommend it to botanists and field biologists in the American Midwest. It contains information that will be useful beyond this geographic range as well.

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## ENVIRONMENT

### Ecology of Fragmented Landscapes

By Sharon K. Collinge. 2009. Johns Hopkins University Press, 2715 North Charles Street Baltimore, Maryland 21218-4363 USA. 340 pages, 70 USD Cloth.

*Ecology of Fragmented Landscapes* is an intriguing look at a growing and increasingly problematic phenomenon: fractured lands that significantly affect biodiversity. Ecologist and evolutionary biologist Sharon Collinge synthesizes decades of research on fragmented landscapes into 12 chapters discussing topics such as fragment size and isolation, animal and plant movement, species interaction, parasites and disease, restoration, and ecological planning. The main purpose of the book is to summarize current knowledge related to fragmented landscapes.

The "Animal and Plant Movement" chapter is particularly interesting. Collinge starts by discussing differing types of animal and plant movement, then points out that in fragmented landscapes species often encounter obstacles in their attempts to travel from one suitable habitat patch to another. She goes on to discuss the highly debated effectiveness of corridors, which have their advantages and disadvantages, and which work for some species and certain situations, but not all—not for the species that "appear to move across landscapes in mysterious and unexplained ways" (page 131), some of which benefit more from stepping stones of habitat patches than from linear corridors.

Collinge stresses that we need to learn more about the conditions in which corridors can be expected to facilitate movement. She points out that it is also essential to better understand movement, along with the ways in which a species' perception and capacity for movement are integrated with landscape patterns.

It is also important to understand interactions in landscapes, as discussed in the "Species Interactions"

chapter. Collinge writes about competition, predation, pollination, seed dispersal, mycorrhizal associations, and herbivory and seed predation—as well as a fascinating and little-studied phenomenon known as "floral larceny" (page 162)—in various negative and positive configurations. She ends the chapter by stressing that many questions remain unanswered, questions that are important in planning and managing landscapes that support rich biodiversity.

In the "Restoration" chapter, Collinge presents a variety of fascinating case studies involving both human and natural landscape restoration. The "Ecological Planning" chapter discusses a wide range of activities and approaches that have as a common denominator the integration of ecological knowledge with deliberate human action and landscape change, from greenways and new urbanism to systematic conservation planning and initiatives such as the Living Landscapes Program and the Wildlands Project.

Collinge leaves us with final thoughts on key concepts and promising research directions. Stressing that many opportunities exist to incorporate current knowledge about fragmented landscapes into actions that will "stem the tide of biodiversity losses and the degradation of ecosystem services" (page 279), she encourages readers to develop creative solutions that will meet landowner and stakeholder needs for information and incentives to make positive landscape change.

*Ecology of Fragmented Landscapes* is a fascinating, thorough, and positive book, packed with scientific and technical content—an excellent resource for teachers and students of landscape and restoration ecology



or for scientifically oriented naturalists. The content may, however, be a little dense for naturalists who are not used to scientific and academic writing and who are looking for an informative, enjoyable, and relatively uncomplicated read. That said, those readers willing

to wade into the material and make the effort to understand it will find the endeavour well worthwhile and will learn a great deal.

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## MISCELLANEOUS

### **Innocents in the Dry Valleys: An Account of the Victoria University of Wellington Antarctic Expedition, 1958-59**

By Colin Bull. 2009. University of Alaska Press, 794 University Avenue, Suite 220, Fairbanks, Alaska 99709 USA. 267 pages, 25 USD Paper.

One of the most remarkable and puzzling Antarctic finds by the *Discovery* expedition was the existence of an inland ice-free valley on the west side of McMurdo Sound. When Robert Scott, William Lashly, and Edgar Evans slogged into the valley in December 1903, it impressed them as "a very wonderful place." It also impressed them by its apparent lifelessness, no doubt reinforced when they also found the mummified remains of a Weddell seal. Scott famously described the valley in his diary as "a valley of death". However, this ice-free terrain, offering good rock exposures, was a magnet to the geologists on Scott's second expedition. In 1911, Griffith Taylor, after whom the valley is named, with Charles ("Silas") Wright, Edgar Evans, and Frank Debenham, spent several days there examining the geology.

Skip forward to the late 1940s, when aerial photography revealed the existence of two more large "dry valleys," now called Wright Valley and Victoria Valley, in the same area. In the austral summer of 1957-1958, Colin Bull tells us, two geology undergrads from Victoria University of Wellington in New Zealand, Barrie McKelvey and Peter Webb, managed to finagle their way onto the team re-supplying New Zealand's Scott Base in Antarctica. Together with Dick Barwick, a junior lecturer in biology at Victoria University of Wellington, Barrie worked in Victoria Valley, until then unexplored. McKelvey and Webb also spent time mapping sandstones and dolerites in Beacon Valley, a tributary of Taylor Valley. Back in New Zealand, they talked enthusiastically about their summer field experience. By coincidence, Colin Bull, then a newly hired physics lecturer fresh from the UK, heard one of their talks. Bull already had several years' field experience in the Arctic carrying out geophysical surveys. He was thinking about trying to initiate fieldwork in Antarctica, having been intrigued by the air photos of the McMurdo Dry Valleys shown to him by Vivian Fuchs during a visit to Cambridge. Bull's target was Wright Valley, located between Victoria and Taylor valleys and so far unexplored. Immediately, he recruited McKelvey, Webb, and Barwick onto his team. They spent several months scrounging up funds and

field supplies, notably by persuading various manufacturers and food suppliers to donate their products, while Bull negotiated the delicate official hurdles to get them to Antarctica. Eventually, the entire expedition was accomplished on a shoestring budget of about \$1,000.

Bull provides a lively and engaging account of their subsequent two-month field season in Wright Valley, with studies encompassing geophysics, geology, and biology. The valley provided plenty of scope for their fieldwork. Stretching inland for about 60 km, the valley is bounded by steep slopes of the Asgard and Olympus ranges. Cliffs are cut in sandstones topped with dolerite, while lower slopes are cut in granites, and igneous dykes protrude along the valley floor. The valley terminates in glaciers at both ends, with moraines providing additional evidence of earlier glacial episodes, while many smaller glaciers spill down side slopes. A large enigmatic ice-covered lake, which they named Lake Vanda, lies toward the west end of the valley and is fed by the Onyx River.

"It really was the most exciting view in all directions, the huge sandstone cliffs, the monstrous icefalls, everything!" exclaims Bull. "How can I tell you easily how excited we all were?" (page 75).

Given the size of the field area and their limited time, they were able to do only preliminary reconnaissance studies. Bull and Barwick did topographic mapping and survey work. Bull carried out a gravity survey to investigate subsurface structure and collected oriented rock samples for palaeomagnetic studies to provide evidence of polar wandering. McKelvey and Webb mapped and characterized the bedrock geology and collected rock samples for their MSc theses. Barwick hunted for life forms, terrestrial and aquatic. They also set up a Stevenson screen and recorded weather observations. All their data were interesting and significant because so little was known about this area.

Beyond the purely scientific objectives, this was a great adventure. Bull describes the vicissitudes of camp life and fieldwork, challenges exacerbated by the remoteness of their field area, which also lent a distinct edge and more than a touch of danger to their

experiences. They were aware that "this beautiful land was also a hideously dangerous place" (page 70). With considerable humour and some great colour photographs, Bull describes the hard work, fun, and rewards of their fieldwork. They definitely needed all their youthful energy and exuberance. Conditions were certainly trying. They were continually blasted by sand carried by the strong winds that constantly blew along the valley. This made carrying their field equipment and taking measurements difficult. The sand also added an unwelcome garnish to their meals. Survey work required getting to heights of land, which entailed some hair-raising scrambles along icy, rocky slopes and ridges. Crossing a glacier, Bull and Barwick experienced a "firnquake." The weather was highly variable, from swelteringly hot to cold and snowy; they lost field days to storms that kept them tent-bound.

Despite the difficulties, Bull characterizes their field season as highly successful when he enumerates their achievements. This was the first expedition to Antarctica organized and planned from a university. They were the first group to visit and undertake scientific work in the Wright Valley. They estimated the depth of Lake Vanda (70 m) and the thickness of the Wilson Piedmont Glacier (250 m). They recorded and examined the mummified penguins and especially seals, of which there were surprisingly many. They found nematodes, rotifers, algae, and lichens growing in this place that seemed lifeless. They documented rain, which wasn't supposed to occur in Antarctica. They did basic geological assessment of about 2600 km<sup>2</sup> of mountainous terrain. They brought back important geophysical, biological, geological, meteorological, and geomorphological observations that formed the basis for many later studies.

Skip forward to 2005 and a reunion. The four of them met up again at an event to celebrate decades of fieldwork at Vanda Station. The reunion was a convivial occasion, with much telling of tales and sharing of field experiences. It was from that reunion that this book grew, with Bull deciphering his field notes and supplementing the account with photographs and field notes from his three colleagues. His reliance on those contemporary records gives this chronicle an immediacy and freshness that are captivating. The narrative was expanded by more reminiscences generated by another reunion in 2007 to celebrate more than 50 field seasons of work in Antarctica by faculty and students from Victoria University of Wellington. As leader of a pioneering field season, Bull is understandably proud of this achievement. Indeed, all team members have much to be proud of. All four contribute concluding essays to this book, summarizing their subsequent careers and, in three cases, their continuing involvement in Antarctic studies. Peter Webb reports that he has "participated in 22 expeditions and spent more than three years south of the Antarctic Circle" (page 226) in the course of his research career. Several of the "big names" in recent polar science are their students or

students of their students. And so their scientific legacy lives on.

Situated midway between the "heroic age" of polar exploration and today, Bull's account provides some thought-provoking comparisons and contrasts. In many ways, the technological, attitudinal, and scientific distance between Bull's fieldwork and Scott's is much greater than between Bull's and today's. Bull's group had radios and could get in touch with McMurdo or Scott bases; they had plenty of food and fuel and were never in danger of starvation; they were flown in to their field area by helicopter instead of man-hauling their gear on sledges from their base. Yet they lacked most electronic gadgets we carry today, especially for communication; surveying was done slowly and painstakingly by theodolite and aneroid barometer rather than by total station and GPS; apart from radio check-ins, their fieldwork was unencumbered by "risk management"; and, by burying or burning their waste and garbage, they were not as concerned with the ecological footprint of their activities.

However, in many ways fieldwork has not changed over the decades. The cold and discomfort of a wet camp, the obsession with food, the hard and tiring physical activity, and the sudden danger from swift weather changes: these are the perils of fieldwork. The exhilarating sense of discovery, the absorption in understanding and interpreting the landscape and biota, and the excitement of exploring new questions generated by observations and measurements: these are rewards of fieldwork that are the same in any climate and any time. So are wry memories of the opportunities missed. When taking survey readings on Mount Jason, Bull describes finding and dismissing a porous piece of sandstone with "a dark line just under the edge" that he thought was simply an odd weathering phenomenon (page 105). Years later, the line was found to be an extremophile endolithic bacterium living in that protected and sheltered microenvironment, one of the subsequent significant scientific discoveries in the McMurdo Dry Valleys.

Why should this account interest anyone other than people who were or are involved in Victoria University's Antarctic fieldwork? At first glance, this appears to be simply a minor historical footnote about an obscure place and esoteric research. It is that, of course, but it is nevertheless well worth reading. Bull presents an enthusiastic historical perspective of what it was really like to do field science. Unfortunately, this book is not well served by its title, which does not indicate what the expedition was about. Moreover, Bull never explains in what way he and his companions were "innocent." Readers expecting a trekking adventure will be surprised by a different kind of endeavour. Those with an interest in Antarctica or the history of polar science will be fascinated and delighted.

ALWYNNE B. BEAUDOIN

Royal Alberta Museum, Edmonton, Alberta, Canada



## Biological Notes on an Old Farm: Exploring Common Things in the Kingdoms of Life

By Glenn B. Wiggins. 2009. Royal Ontario Museum, Toronto Ontario M5S 2C6

The author dedicated this book to his wife, Carol, and then noted: "and for curious observers who take time to look".

This is an unusual book in many ways. It includes information on all living land-based organisms – bacteria, plant and animal (in accordance with the title). It is exceptionally well illustrated with colour photographs, colour and black-and-white paintings – the colour plates of plants and invertebrate animals are exceptional – and numerous drawings and sketches on the margins of the text pages. The writing is clear, concise and most readable.

In the prologue, the author describes how the book arose, that the primary organization is based on the classification system for the Kingdom of Life. Within the prologue is a geological time-table showing geological ages, based on the fossil record for major groups in the Kingdom of Life.

A brief introduction to Oakdale Farm – (author's farm) follows, accompanied with an overview of the changes of life style from family farm to city dwellers, the appearance of summer cottages and the re-occupation of the small farms and finally the recognition of advancing age and the personal necessity of a less rustic lifestyle.

The text follows an evolutionary sequential pattern with informative discussions. When considering the spring-flowering Trillium, for example, the author notes that the plant requires many years of growth before it can produce seeds. Thus the grazing by deer and free-ranging cattle can have a devastating effect on the survival of this particular wildflower.

Then follows a discussion on the role of ants in the dispersal of Trillium seed.

This type of in-depth discussion concerning the welfare of a particular plant or animal group and its relationship with the environment, is continued throughout the book.

The discussion of beetles is fascinating, not only because of the sheer numbers "...one in every four known species in the entire Animal Kingdom is a beetle" but because of its long association with man. A scarab beetle was a prominent religious symbol in early Egyptian civilization. Our June beetle is a scarab. Many other beetle species are discussed and illustrated including fire flies, potato beetles, lady beetles and click beetles.

The accounts continue with the true flies, wasps, caddisflies and moths to the Fungal Kingdom, which includes the lichens. The concept of a functional sym-

biosis between a fungus and an algae was initially rejected by British biologists but was successfully supported by the scientific work of Beatrix Potter, who later became famous as the creator of Peter Rabbit books.

In a separate chapter 6, entitled 'Kingdoms of Life, Cyanobacteria and Photosynthesis', a serious discussion is presented concerning the roles of bacteria, cyanobacteria, algae and photosynthesis in the origin of life. A summation is presented in the following quotation:

'Photosynthesis with oxygen as its by-product, arguably one of the most important evolutionary innovations in Earth's entire history, began with Cyanobacteria more than 3 thousand million years ago'.

A section entitled the entomology of old houses discusses the wide variety of small creatures that have learned to share our homes, our clothes and our food. Included are carpet beetles, crickets, clothes moths, silverfish, sow bugs and spiders. The section includes a discussion of stored food insects – again with excellent illustrations, especially the clothes moth.

At the end of the book, chapter 8 is a discussion of life in temporary pools or ponds. This is clearly a habitat of special interest to the author and the many life forms are treated in detail, again with numerous illustrations of larvae and adults of the inhabitants of the pools, including mollusks, flatworms, worms, bryozoans, mayflies, caddisflies, dragonflies, diving beetles, water bugs and amphibians.

The problems associated with the life forms able to adapt to the conditions prevailing in such an environment are thoroughly discussed. The author concludes that at least 65 families of organisms have become adapted to the flood and drought cycles of temporary pools.

A beautiful book in many respects, not only because of the artwork, which is exceptional, but also because of the breadth of the information presented. The book was designed by the author.

An initial reading of this review may leave the impression that the book is too technical for the general reader – that would be an incorrect assessment.

Yes, the initial sequential arrangement of the material is technical, but the subjects and the written discussions are of broad general interest.

The author must be very proud of his efforts.

W. B. SCOTT

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## Biological Notes on an Old Farm: Exploring Common Things in the Kingdoms of Life

By Glenn B. Wiggins. 2009. Royal Ontario Museum, Toronto Ontario M5S 2C6. xvii + 359 pages

I eagerly opened this book because, like Glenn Wiggins, I am a museum biologist who bought an old farm in eastern Ontario years ago. Also, I had identified tadpole samples for him when he was writing a benchmark contribution on the life of temporary ponds, a habitat which features prominently in this book.

Our perspectives, however, differed. Wiggins found his farm in rocky elevation of the Canadian Shield outcropping of the Frontenac axis northeast of Kingston. In contrast, we bought on the limestone plain former Champlain seabed southwest of Kemptville. Wiggins is an invertebrate zoologist and I am a vertebrate one. But we shared intense interest in and study of the fauna around us and by reflex compiled inventories of our properties. Wiggins has produced this book from his experience. It is focused, as one would expect from his career in invertebrate studies, on these animals.

Throughout it is illustrated by black-and-white drawings of both vertebrates and invertebrates, from a variety of artists and including some by Charlie Douglas from my *Introduction to Canadian Amphibians and Reptile* reproduced with permission. But the bulk were the work of the late staff artist of the Royal Ontario Museum, E. B. S. Logier and others.

Wiggins' text approach is unique. The book combines an invertebrate textbook account of significant features of the invertebrate groups covered and a local inventory of them. The result is a readable account of often overlooked life by the majority of naturalists who focus almost exclusively on vertebrates, with birds being the primary group of choice. Wiggins shows that the fascinating diversity and roles of invertebrates are as worthy of the attention of naturalists and provides a background survey as a starter kit for their further study.

No book is flawless, and for a herpetologist a minor jarring note was the reference to "Cricket Frogs" calling in the area in spring. The frog meant is the Chorus Frog (*Pseudacris triseriata*), which was formerly known as the "false cricket frog" after its generic name. The true Cricket Frog (*Acris gryllus*) was formerly restricted, in Ontario, to Pelee Island and Point Pelee, but is now apparently extirpated at both.

The book is a classic that deserves to be on every naturalists shelf. Its relevance is far beyond Ontario and will serve to dip into for occasional reference or as the inspiration for a new direction in study.

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## NEW TITLES

Prepared by Roy John

† Available for review \* Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

## ZOOLOGY

**Notes from the Book Review Editor**

Moving with the times, I am including a notice that Princeton University Press has an iPhone app for *Birds of the Dominican Republic and Haiti* by Steven Latta, Christopher Rimmer, Allan Keith, James Wiley, Herbert Raffaele, Kent McFarland, and Eladio Fernandez (Princeton Field Guides, 2006). All proceeds go to the disaster relief effort. See <http://press.princeton.edu/blog/2010/06/02/the-birds-of-the-dominican-republic-and-haiti-iphone-app-available-all-proceeds-go-to-disaster-relief>.

In a second development, a new birding app for the iPhone and iPod Touch called **BirdsEye** has been released by Birds in the Hand, LLC, of Virginia. It incorporates sound (Cornell Lab of Ornithology), photos (the Academy of Natural Sciences), and text (by Ken Kaufman). BirdsEye provides real-time access to bird observations in the Cornell Lab eBird database. For a specific bird, BirdsEye will show you where it has been observed recently and will give you directions. There is full information on 470 common species and additional material on 386 rare species. A second version, BirdsEye Lite, incorporates 135 of the commonest species. More information is at <http://www.getbirdseye.com>.

**AAAAW TO ZZZZZD: The Words of Birds — North America, Britain, and Northern Europe.** By John Bevis. 2010. MIT Press Bookstore, Kendall Square, 292 Main Street, Cambridge, Massachusetts 02142. 160 pages, 12.95 USD, Cloth.

**The American Bird Conservancy Guide to Bird Conservation.** By George H. Fenwick, Daniel J. Lebbin, and Michael J. Parr. Forthcoming. University of Chicago Press, 1427 East 60th Street Chicago, Illinois 60637. 450 pages, 45.00 USD, Cloth.

**Atlas of Rare Birds.** By Dominic Couzens. 2010. MIT Press Bookstore, Kendall Square, 292 Main Street, Cambridge, Massachusetts 02142. 240 pages, 29.95 USD, Cloth.

**Avian Invasions: The Ecology and Evolution of Exotic Birds.** By Tim M. Blackburn, Julie L. Lockwood, and Phillip Cassey. 2010. Oxford University Press, New York, New York. 320 pages, 33 EUR.

**The Bird Detective: Investigating the Secret Lives of Birds.** By Bridget Stutchbury. 2010. HarperCollins Canada Ltd., 2 Bloor Street East, 20th Floor, Toronto, Ontario M4W 1A8. 272 pages, \$32.99 CAD, Cloth.

\* **Birds of Australia.** Eighth edition. By Ken Simpson and Nicolas Day. 2010. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237. 392 pages, 39.50 USD, Cloth.

**Birds of Mongolia.** By S. Gombobaatar and A. Braunlich. Forthcoming. Helm Publishing, P.O. BOX 9691, Treasure Island, Florida 33706 224 pages, 27.8 EUR.

**Birds of Peru.** Revised edition. By Thomas S. Schulenberg, Douglas F. Stotz, Daniel F. Lane, John P. O'Neill, and Theodore A. Parker III. 2010. Princeton University Press, 41 William Street, Princeton, New Jersey. 664 pages, 39.50 USD, Paper.

**Birds of the Middle East.** Second edition. By R. Porter and S. Aspinall. 2010. Christopher Helm Publishers Ltd., 38 Soho Square, London W1D 3HB UK. 400 pages, 33.50 EUR, Paper.

\* **Birds of the West Indies.** By Norman Arlott. 2010. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237. 240 pages, 24.95 USD, Paper.

**Butterflies.** By P. Howse. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 192 pages, 39.95 CAD, Cloth.

**Butterfly.** By T. Marent. 2010. Dorling Kindersley, Tourmaline Editions Inc., 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7. 280 pages, 22.95 CAD, Paper.

\* **Coastal Fishes of the Pacific Northwest.** 2010. Revised and expanded second edition. By A. Lamb and P. Edgell. Harbour Publishing, PO Box 219, Madeira Park, British Columbia V0N 2H0. 338 pages, 29.95 CAD, Paper.

**Concise Bird Guide.** By Nicholas Hammond. 2010. New Holland Publishers (UK) Ltd., Garfield House, 86-88 Edgware Road, London W2 2EA UK. 216 pages, 5.5 EUR.

**Coyote at the Kitchen Door.** By S. DeStefano. Harvard University Press, 9 Garden Street, Cambridge, Massachusetts 02138. 24.95 USD.

**The Crossley ID Guide: Eastern Birds.** By Richard Crossley. Forthcoming. Princeton University Press, 41 William Street, Princeton, New Jersey. 528 pages, \$35.00 USD, Flexibound.

**The Eagle Watchers: Observing and Conserving Raptors around the World.** Edited by Ruth E. Tingay and Todd E. Katzner. 2010. Cornell University Press, Sage House, 512 East State Street, Ithaca, New York 14850. 256 pages, 29.95 USD, Cloth.

**A Field Guide to Nudibranchs of the Pacific Northwest.** By Rick M. Harbo. 2010. Harbour Publishing, PO Box 219, Madeira Park, British Columbia V0N 2H0. 2 pages, 7.95 CAD, Pamphlet.

**Field Guide to the Birds of Macronesia.** By E. Garcia-del-Rey. 2010. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 280 pages, 28 EUR, Cloth.

**Frog.** By T. Marent and Dorling Kindersley. 2010. Tourmaline Editions Inc., 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7. 280 pages, 22.95 CAD, Paper.

**The Golden Eagle.** Second edition. By J. Watson. 2010. Helm Publishing, P.O. BOX 9691, Treasure Island, Florida 33706 464 pages, 50.00 EUR.

**Keeping the Bees.** By Laurence Packer. 2010. HarperCollins-Publishers Ltd., 1995 Markham Road, Scarborough, Ontario M1B 5M8. 272 pages, 29.99 CAD, Cloth.

**New Perspectives on Horned Dinosaurs: The Royal Tyrrell Museum Ceratopsian Symposium — Life of the Past.** Edited by Michael J. Ryan, Brenda J. Chinnery-Allgeier, and David A. Eberth. 2010. Indiana University Press, 601 North Morton Street, Bloomington, Indiana 47404-3797. 648 pages, 110.00 USD, Cloth.

**\* Nightjars, Potoos, Frogmouths, Oilbird, and Owlet: Nightjars of the World.** By Nigel Cleere. 2010. Princeton University Press, 41 William Street, Princeton, New Jersey. 464 pages, 45.00 USD, Cloth.

**Ocelis de Catalunya, Pais Valencia I Balears.** [in Catalan] By J. Estrada, F. Jutglar, and T. Llobet. 2010. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 280 pages, 20.00 EUR.

**Reed & Bush Warblers.** By Peter Kennerley and David Pearson. 2010. Helm Publishing, P.O. BOX 9691, Treasure Island, Florida 33706. 712 pages, 64.00 EUR.

**Sparrows.** By G. and M. Oliosio. 2010. New Holland Publishers (UK) Ltd., Garfield House, 86-88 Edgware Road, London W2 2EA UK. 180 pages, 16 EUR.

**Where to Watch Birds in Britain.** By Nigel Redman and Simon Harrap. 2009. Christopher Helm Publishers Ltd., 38 Soho Square, London W1D 3HB UK. 640 pages, 22.25 EUR.

**The World of the Polar Bear.** By N. Rosing. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 216 pages, 29.95 CAD, Paper.

## BOTANY

**A Field Guide to Coastal Flowers of the Pacific Northwest.** By Phillipa Hudson. 2010. Harbour Publishing, PO Box 219, Madeira Park, British Columbia V0N 2H0. 2 pages, 7.95 CAD, Pamphlet.

**Mushrooms and Other Fungi of North America.** By R. Phillips. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill Ontario L4B 1H1. 384 pages, 29.95 CAD, Paper.

**Wild Urban Plants of the Northeast: A Field Guide.** By Peter Del Tredici. 2010. Cornell University Press, Sage House, 512 East State Street, Ithaca, New York 14850. 392 pages, 29.95 USD, Paper.

## ENVIRONMENT

**Atlas of Biodiversity Risk.** Edited by Josef Settele, Lyubomir Penev, Teodor Georgiev, Ralf Grabaum, Vesna Grobelnik, Volker Hammen, Stefan Klotz, Mladen Kotarac, and Ingolf Kuehn. 2010. Pensoft Publishers, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 280 pages, 99.00 EUR, Cloth.

**\* The Changing Arctic Landscape.** By Ken Tape. 2010. University of Chicago Press, 1427 East 60th Street, Chicago, Illinois 60637. 132 pages, 35.00 USD, Cloth.

**Earth Then & Now.** By F. Pearce. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill Ontario L4B 1H1. 288 pages, 19.95 CAD, Paper.

**\* Essentials of Conservation Biology.** Fifth Edition. By Richard B. Primack. 2010. Sinauer Associates, Inc., 23 Pluntree Road, P.O. Box 407, Sunderland, Massachusetts 01375-0407. 538 pages, 86.95 USD, Cloth.

**Natural Sable Island.** By Z. Lucas. 2010. Nimbus Publishing Ltd., P.O. Box 9166, Halifax, Nova Scotia B3K 5M8. 112 pages, 21.95 CAD, Paper.

**Planet Arctic.** By W. Lynch. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 240 pages, 40 CAD, Cloth.

**Rainforest.** By T. Marent. 2010. Dorling Kindersley, Tourmaline Editions Inc., 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7. 360 pages, 27.95 CAD, Paper.

**Wild Africa.** By A. Bernasconi. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 288 pages, 49.95 CAD, Cloth.

## MISCELLANEOUS

**Amber: The Natural Time Capsule.** By Andrew Ross. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 112 pages, 29.95 CAD, Cloth.

**Essential Ornithology.** By Graham Scott. 2010. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario M3C 1J9. 208 pages, 55 USD, Paper.

**The Field Guide to Natural Phenomena.** By K. Heidhorn and I. Whitelaw. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 224 pages, 24.95 CAD, Paper.

**Guide to Gems.** By C. Oldershaw. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 224 pages, 16.95 CAD, Paper.

**Guide to Minerals, Rocks and Fossils.** By A. C. Bishop, A. Woolley, and W. Hamilton. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 336 pages, 19.95 CAD, Paper.

**Microcosmos.** By B. Broll. 2010. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 224 pages, 19.95 CAD, Paper.



**Natural History.** By Dorling Kindersley, [Forthcoming].  
Tourmaline Editions Inc., 662 King Street West, Suite 304,  
Toronto, Ontario M5V 1M7. 648 pages, 55.00 CAD, Cloth.

**Super Species.** By G. Hamilton. 2010. Firefly Books Ltd.,  
66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 272  
pages, 35 CAD, Cloth.

\* **The Practical Naturalist.** 2010. By Dorling Kindersley,  
Tourmaline Editions Inc., 662 King Street West, Suite 304,  
Toronto, Ontario, M5V 1M7. 256 pages, 19.95 CAD, Paper.

## News and Comment

### Sixth Annual Meeting of the Alliance of Natural History Museums of Canada, 26 and 27 October 2009

Leaders of Canada's major natural history museums convened in Ottawa on 26 and 27 October 2009 for the sixth annual meeting of the Alliance of Natural History Museums of Canada (ANHMC). The network was created in 2003 to enhance collaborative work in the areas of research, collections development, and education about the natural environment. Pauline Rafferty, CEO of the Alliance and Director of the Royal British Columbia Museum, stressed the continuing national strategy for developing a collection that will represent all of Canada's biodiversity.

The Alliance's 16 members from west to north to east are the Royal British Columbia Museum, the Vancouver Aquarium, the Royal Alberta Museum, the Royal Tyrrell Museum of Palaeontology, the Yukon Beringia Interpretive Centre, the Prince of Wales Northern Heritage Centre, the Royal Saskatchewan Museum, the Manitoba Museum, the Royal Ontario Museum, the Canadian Museum of Nature, the Toronto Zoo, Montreal's nature museums (Biodôme, Insectarium, Botanical Gardens, and Planetarium), the Redpath Museum (Montreal), the New Brunswick Museum, the Nova Scotia Museum of Natural History, and The Rooms Provincial Museum, Newfoundland and Labrador. These institutions are responsible for preserving the record of Canada's natural history through time. Together, member museums safeguard more than 19 million catalogued specimens of plants, animals, minerals, and fossils collected over 150 years. The purpose of the national collections strategy is to ensure that this crucial record is complete and is preserved in perpetuity.

At a special reception held the evening of 27 October on Parliament Hill, the third annual Bruce Naylor Award was presented. This honour recognizes significant contributions to the study of museum-based natural history in Canada. The 2009 recipient was Dr. Robert Cannings, a notable entomologist from British Columbia. Dr. Cannings' contributions as a biologist go back decades, from his early days as a naturalist and nature interpreter to his 29 years as Curator of Entomology at the Royal British Columbia Museum in Victoria. He has authored several books, published more than 100 peer-reviewed scientific articles, and written over 100 popular articles. Under his curatorship, the Museum's entomology collection has grown from a few thousand specimens to the present collection of over 250 000. He has also written text for, and contributed to the planning of, a wide range of museum

exhibits. While he publishes on many kinds of insects, his research focuses on the diversity and evolution of dragonflies and robber flies. Books that he has authored or co-authored include *The Dragonflies of British Columbia* (1977), *The World of Fresh Water* (1998), *Introducing the Dragonflies of British Columbia and the Yukon* (2002), and *The Systematics of Lasiopogon (Diptera: Asilidae)* (2002). He joined forces with his brothers, biologists Sydney and Richard, to produce *Birds of the Okanagan Valley* (1987), and his artistic talents were put to use illustrating the White-headed Woodpeckers on the book's cover. For many years he has served on the executive of the Entomological Society of British Columbia and he was editor of the Society's newsletter *Boreus* (which he started in 1981) until 1991. He is a member of the Arthropods Subcommittee of COSEWIC (Committee on the Status of Endangered Wildlife in Canada) and the British Columbia Invertebrate Recovery Team. He has also been active on the Scientific Committee of the Biological Survey of Canada (Terrestrial Arthropods).

"The thing that I've always tried to do is be broad in my interests, rather than always simply focusing on particular research and collections projects," says Dr. Cannings. "I've tried to be a bit of everything. I like to think this award recognizes that versatility."

Periodically he teaches at the University of Victoria and he has brought fourth-year students into the Museum's labs to give them direct exposure to the kind of work done by museum biologists.

"I have never known anyone so well-rounded and devoted," says Mr. Kelly Sendall, Manager of Natural History at the Royal British Columbia Museum. "In my mind he is the epitome of what a curator in a natural history museum should be."

Cannings grew up in Penticton in the Okanagan Valley. His father was the photographer for the Agriculture Canada research station in Summerland. The young Cannings frequently hung around with the scientists. An amateur biologist, his father often took the family to the Penticton museum, and at times they would donate things they found in nature to the museum.

"I was a museum kid long before I ever came here," says Cannings. "Natural history and collecting were part of our life."

Cannings recalls that his family had a long shelf of natural history books, including handbooks produced by the Royal British Columbia Museum (formerly the



British Columbia Provincial Museum). Even when he was young, one of his ambitions was to write a museum handbook. His goal was realized with *The Dragonflies of British Columbia*, which was published before he joined the Royal British Columbia Museum

in 1980. In 2008, Okanagan University College named Dr. Cannings and his two brothers as honorary fellows for their contributions to the appreciation of nature through their writings, professional activities, and dedication.

### **Canadian Association of Herpetologists Bulletin Association Canadienne des Herpétologistes 16(2) Spring 2009**

Editor – Jacqueline D. Litzgus, Department of Biology, Laurentian University, Sudbury, Ontario P3E 2C6 Canada; e-mail: jlitzgus@laurentian.ca, 705-675-1151 ext 2314

Contents: Instructions for Authors — EDITORIAL NOTES — UPCOMING MEETINGS — FEATURE ARTICLE: Silent Spots in the Wetland by Jacqueline Litzgus — FIELD NOTES: What is a Snapping Turtle? by Shane de Solla — BOOK REVIEW: Review of Biology of the Snapping Turtle (*Chelydra serpentina*) by Shane de Solla — THESIS ABSTRACTS IN CANADIAN HERPETOLOGY: **Joshua Amiel**, B.Sc. 2009, Dalhousie University, Halifax, Nova Scotia (Supervisor: Richard Wassersug) Physiological and behavioural adaptations of the Eastern Ribbonsnake (*Thamnophis sauritus*) to cold climates; **Hillary Black**, B.Sc. 2009, Laurentian University, Sudbury, Ontario (Supervisor: Jacqueline Litzgus) The effects of body mass and temperature on the standard metabolic rate of

three species of colubrid snakes; **Kevin Little**, B.Sc. 2009, Laurentian University, Sudbury, Ontario (Supervisor: David Lesbarrères) Factors affecting the virulence of Frog Virus 3 on Northern Leopard Frog (*Rana pipiens*) tadpoles; **D. Marcil-Ferland**, B.Sc. 2009, University of Ottawa, Ottawa, Ontario. (Supervisor: Gabriel Blouin-Demers) Geometric morphometrics offer insight on the intersexual differences in allometric coefficients of bite force in the northern map "University of Ottawa, Ottawa, Ontario (Supervisor: Gabriel Blouin-Demers) Factors affecting leech parasitism on four turtle species in St. Lawrence Islands National Park — RECENT PUBLICATIONS IN CANADIAN HERPETOLOGY — NEWS AND ANNOUNCEMENTS — Membership Form.

### **Canadian Association of Herpetologists Bulletin Association Canadienne des Herpétologistes 17(1) Fall 2009**

Contents: EDITORIAL NOTES — MEETINGS — What I did on my summer vacation (review of the JMIH and a field trip to Turtleworld) by Leslie Anthony — FEATURE ARTICLE: The Father of Canadian Herpetology: An Autobiography by Sherman Bleakney — BOOK REVIEWS: Review of *Mean and Lowly Things* (Kate Jackson) by Leslie Anthony; Review of *Snakebit* (Leslie Anthony) by Pat Gregory — THESIS ABSTRACTS IN CANADIAN HERPETOLOGY: **Amanda Bennett**, M.Sc. 2009, Laurentian University, Sudbury, Ontario (Supervisor: Jacqueline Litzgus), Effects of habitat fragmentation on the spatial ecology and genetics of Northern Map Turtles (*Graptemys geographica*); **Gregory Bulté**, Ph.D. 2009, University of Ottawa, Ottawa, Ontario (Supervisor: Gabriel Blouin-Demers), Sexual dimorphism in Northern Map Turtles (*Graptemys geographica*): ecological causes and consequences; **Jose Lefebvre**, M.Sc. 2009, Acadia University, Wolfville, Nova Scotia (Supervisor: Tom Herman), Marrying conservation and exploitation: combining integrated resource management plans (IRMs) and the Blanding's Turtle (*Emydoidea blandingii*) to conserve and manage wetland ecosystems in Nova Scotia; **D. Marcil-Ferland**, B.Sc. 2009, University of Ottawa, Ottawa, Ontario (Supervisor: Gabriel Blouin-Demers),

Geometric morphometrics offer insight on the intersexual differences in allometric coefficients of bite force in the Northern Map Turtle (*Graptemys geographica*); **Abigail Pattishall**, Ph.D. 2008, Lehigh University, Bethlehem, Pennsylvania (Supervisor: David Cundall), The ecology of synurbic watersnakes; **A. C. Plumer**, M.Sc. 2009, University of Ottawa, Ottawa, Ontario (Supervisor: Gabriel Blouin-Demers), Thermal preference and the effects of food availability on components of fitness in the bearded dragon, *Pogona vitticeps*; **Marie-Pier Prairie**, M.Sc. 2009, McGill University, Montreal, Quebec (Supervisor: David Green), Landscape ecology of an amphibian community in southern Québec, Canada; **Megan Rasmussen**, M.Sc. 2009, Laurentian University, Sudbury, Ontario (Supervisor: Jacqueline Litzgus), Habitat selection, foraging ecology, and maternal investment in a Lake Huron population of Spotted Turtles (*Clemmys guttata*): implications for conservation and management; **N. Reshke**, B.Sc. 2009, University of Ottawa, Ottawa, Ontario (Supervisor: Gabriel Blouin-Demers), Factors affecting leech parasitism on four turtle species in St. Lawrence Islands National Park — RECENT PUBLICATIONS IN CANADIAN HERPETOLOGY — NEWS AND ANNOUNCEMENTS.

**Marine Turtle Newsletter Number 126 (October 2009)**

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## The Ottawa Field-Naturalists' Club Awards for 2008

IRWIN M. BRODO, CHRISTINE HANRAHAN, DIANE LEPAGE, AND ELEANOR ZURBRIGG

On 25 April 2009, members and friends of the Ottawa Field-Naturalists' Club (OFNC) gathered at the Club's annual Soirée at St. Basil's Church in Ottawa, and once again, awards were given to members and one non-member who distinguished themselves by accomplishments in the field of natural history and conservation

or by extraordinary activity within the Club. Careful observation of plants and animals, political savvy, selfless service, and teaching skills are all in evidence among the 2008 winners. The following citations for those who received an award were read to the members and guests assembled for the event.

### Christine Hanrahan — Honorary Member

This award is presented in recognition of outstanding contributions by a member or non-member to Canadian natural history or to the successful operation of the Club. Usually people awarded an honorary membership have made extensive contributions over many years.

Christine Hanrahan could be receiving this award to honour over two decades' worth of dedicated investigation and documentation of the flora and fauna in natural areas in Ontario and British Columbia or for countless hours of footslogging on personal bioblitzes, which have added to the knowledge of the natural history of such places as Colony Farm, DeBoville Slough, Burke Mountain, and Douglas Island in British Columbia and Petrie Island, Larose Forest, and the Fletcher Wildlife Garden (FWG) in our local area.

Christine could also be receiving this award as a writer for her outstanding contributions in education. Web articles and brochures, such as "How to Get Started in Birdwatching?", "Creating a Safe Garden for Birds," "Trees and Shrubs for Birds," "Wildflowers of the Fletcher Wildlife Garden," and "The Ruddy Duck in Eastern Ontario" are a few examples. She is also a major contributor to *Trail & Landscape*, writing the regular Fletcher Wildlife Garden updates, reports from the Ontario Breeding Bird Atlas project, and a series of articles on small mammals. In more than 25 years of contributions, Christine has had over 60 articles published in *Trail & Landscape*. In recent years, the OFNC website cannot be visited without seeing Christine's contributions: from the home page photo to general interest articles, species lists, the FWG Blog, Larose Forest reports, and her latest project, the PBase photo galleries.

This award might also be given for longstanding Club service in committee work. Christine has worked long hours with committees of the OFNC and other nature-oriented organizations. Always an effective and committed committee member, Christine has served on the Birds, FWG Management, Conservation, and Awards committees. Where did Christine find the time for non-Club activities like being Regional Coordinator for the First (1983–1986) and Second (2000–2005) Ontario Breeding Bird Atlases for the Ottawa region with a team of 120 volunteers, checking and verifying data, and writing final reports? Annually Christine helps organize the Wildlife Festival, a major event with multiple activities attracting large public participation. Christine's name will always be associated with the Larose Forest, a special place for her, where she currently represents the OFNC on the Larose Forest Advisory Committee and in 2008 chaired the Larose Forest 80th Anniversary celebrations. There are many, many other activities which benefit from Christine's organization, support, and leadership.

Christine Hanrahan is receiving this award—an honorary membership in the Club—to recognize and acknowledge the astonishing depth of her love and caring for everything natural and the efforts she has undertaken to make people "see the beauty and the wonder of even the tiniest creature or plant." She has taken almost every opportunity one can imagine to promote the interest of the public in natural history, believing that the more people learn about a species or habitat, the more respect they will have for it and be willing to protect it. Christine is truly an amazing field-naturalist.

### Diane Lepage — Member of the Year

The OFNC's Member of the Year award recognizes the member judged to have contributed the most to the Club in the previous year. Diane Lepage is the 2008 Member of the Year for her dedicated work as a volunteer at the Fletcher Wildlife Garden (FWG).

Diane, who has been an OFNC member since 1980, joined the FWG Management Committee in 2004 and almost immediately became an integral part of the

FWG group. For some years, the FWG committee had debated whether it was worthwhile continuing to maintain the butterfly meadow. The task seemed quite overwhelming and so no decision either way was made until Diane arrived. She saw the potential for rejuvenating the existing site as well as creating a new addition to the meadow. During preliminary visits to the site, she was impressed by the number of butterflies and other

insects she found, and was more than ever resolved to undertake some serious work there. She drafted plans for the site, including lists of plants, and gave them to the committee for input. By 2006 she had rounded up a dedicated team of volunteers who come every Wednesday evening from spring to mid-September. However, it was during 2008 that Diane redoubled her efforts, and there was a remarkable transformation of the new section of the meadow into a place of flourishing blooms where insects are abundant until late fall. Early in 2008, she arranged for further roto-tilling of the area, after which she and her team removed the invasive Dog-strangling Vine, as they had done in previous years, preparing the site for more planting. Plans for 2009 are ambitious and include more roto-tilling, more Dog-strangling Vine control, and planting for nectar and for larval food. She also plans to continue work on

rejuvenating the old butterfly meadow by carrying on with intensive Dog-strangling Vine removal, control of Sumacs (which are invading the meadow), and of course, more planting.

Diane's involvement with the Fletcher Wildlife Garden is not confined to the butterfly meadow. As noted, she is an important member of the FWG Management Committee. She continues to help with invasive plant removal from the amphibian pond; maintains the binder of FWG minutes, making sure we have a complete set of these minutes available; prints the FWG brochures and information sheets; maintains the FWG library; and leads walks.

For all of these reasons, and with a focus on achievements in 2008, we believe that Diane is a fitting recipient of the 2008 Member of the Year Award.

### **Phillip Jeffreys — George McGee Service Award**

The OFNC George McGee Service Award is given in recognition of a member who has contributed significantly to the smooth running of the Club over several years.

Phil Jeffreys has been an active member of the Excursions and Lectures Committee for a number of years and has made valuable contributions to the work of the committee. Seven years ago, Phil volunteered to seek a new location for our annual Soirée, eventually choosing the convenient and affordable St. Basil's Church. Since then Phil has taken charge of the general arrangements for the Soirée at this venue, working out a convenient floor plan, setting up and taking down exhibit structures, and designing and constructing several components in his workshop that facilitate this process and that add to the aesthetics of the scheme. Phil is responsible for phoning potential exhibitors to ensure meaningful participation from Club members, and he organizes a cadre of capable people to help. He

is our liaison with St. Basil's, booking the hall each year, arranging for the sound equipment, and renting the dishes so that we can all enjoy a very festive occasion.

Phil has also taken on the responsibility of hiring buses for our longer trips, such as the spring birding trip to Point Pelee, and for making our hotel bookings. He never fails to check, and double-check, with the hotels and bus companies to make sure that all arrangements are in place, and he sees to the comfort of all the participants.

Many thoughtful ideas and suggestions for improving and adding to Club events and for enhancing the Club's profile in the community in general have also come from Phil in his capacity as a member of the Excursions and Lectures Committee.

For these reasons and more, we wish to honour Phillip Jeffreys with the George McGee Service Award for 2008.

### **Kenneth W. McRae — Conservation Award (Non-member)**

The Conservation Award for a non-member is given in recognition of an outstanding contribution by a non-member to the cause of natural history conservation in the Ottawa Valley, with particular emphasis on activities within the Ottawa District.

Ken McRae is the recipient of the 2008 award to recognize his exceptional efforts as a champion of water resources, concentrating on wetlands in the Ottawa area while also monitoring other issues in eastern Ontario and in provincial legislation. Ken is extremely hard-working and dedicated, and he has become very knowledgeable about wetland protection and related development issues. All of this work has been done as a volunteer while holding down a full-time job.

Ken identifies problems primarily by monitoring the Ontario Environmental Registry, where all environ-

mental changes requiring government approval are posted, such as permits to remove water or amendments to municipal zoning by-laws. The problems that Ken so identifies are then researched exhaustively, and detailed briefs are presented to appropriate authorities and followed up diligently. Some issues go on for many years, making it difficult for any one person to continue to address them, but Ken persists with fortitude.

Copies of his correspondence are circulated to a large number of people interested in protecting wetlands—which may include local politicians and government staff—alerting them to possible negative effects of planned activities. This information serves to raise or enhance awareness and to facilitate participation in decision making regarding management of our environment. Ken's actions serve as a model to residents of



Ontario to exercise their rights under the Environmental Bill of Rights and help to improve government decision making on the environment.

Lately Ken has focused on preserving Ottawa's Goulbourn Wetland Complex, on permits to take water that have an impact on wetlands such as the Leirtrim wetland, and on environmental issues pertaining to quarries and golf courses. Other issues that Ken has

grappled with include the class environmental assessment for the Highway 7 expansion, the treatment of provincially wetlands under the City of Ottawa Official Plan, and drainage issues under the Drainage Act. In past years, he served as a member of the Friends of the Jock River.

Ken McRae is a worthy recipient of the Conservation Award (non-member) for 2008. Congratulations!

### **Stanley D. Rosenbaum — Conservation Award (Member)**

The Conservation Award for Members is presented in recognition of an outstanding contribution by a member of the OFNC in the cause of natural history conservation in the Ottawa Valley, with particular emphasis on activities within the Ottawa District. Stan Rosenbaum is chosen as the recipient for 2008 in recognition of his long and dedicated service to the smooth running of the Conservation Committee.

Stan really is the public face of conservation for the OFNC and has been for many years. He won this same award in 1999 for his work in turning around the Conservation Committee, which was undergoing a crisis of confidence at that time. Now we believe that his remarkable contribution to conservation deserves to be recognized again. Stan is the guiding light of the Conservation Committee, and without him at the helm, many issues would not be addressed.

A long-time member of both the OFNC and the Canadian Parks and Wilderness Society, and closely involved with the Greenspace Alliance, Stan has been interested in the outdoors for many decades. When he retired he decided that it was time to devote more energy and time to the protection of our natural areas. The issues that he has been involved with over the last 12 years are numerous.

On behalf of the OFNC Conservation Committee, Stan has written countless letters to all levels of government, on a wide variety of issues. Topics include the quarry proposal for 5309 Bank St. (the old South Gloucester conservation area); Leirtrim Wetlands; support for a campaign to ban cosmetic use of pesticides; Provincial Planning Reform; protection of the Carden Alvar and the Braeside Alvar; the issue of development in Gatineau Park; Bill 184 (Ontario's Endangered Species Act, 2007)—the list goes on and on. These letters take considerable research and time to prepare, and the facts and arguments are checked, and then checked again, and checked once more, before they are

sent. Thanks to Stan, the credibility of the OFNC on conservation matters continues to be maintained.

Stan has also attended innumerable open houses on issues ranging from expansion of the Nortel property into the National Capital Commission greenbelt, Lands for Life, Ontario Parks legislation review, South March Highlands management plan, and Planning Act regulations, to name only a few of the many.

In 2008, Stan led the OFNC's objection to the White Paper released by the City of Ottawa to test public reaction to developing parts of the greenbelt; the City withdrew the paper.

As if all of this is not enough, Stan has represented the OFNC on many coalitions and working groups. These include, but are not limited to, the Light Rail Maintenance Yard Public Working Group, the NCC Renewal Coalition, the Gatineau Park Protection Coalition, and the Greenbelt Coalition.

In addition to the above-mentioned letters, Stan frequently prepares well-researched briefs presenting the conservation point of view on many of the above issues.

Additionally, when the call went out from the Ontario Ministry of Natural Resources in 2008 for help in eastern Ontario with a hands-on project to remove the invasive Water Chestnut, Stan was right there. He not only helped find volunteers, but volunteered for field work himself.

Stan not only chairs the Conservation Committee, he also serves as committee secretary, preparing the agenda beforehand and the minutes afterwards. These excellent summaries are used to prepare the quarterly Conservation Matters articles for *Trail & Landscape*. Stan also writes annual reports on committee activities for the OFNC Council and brings important issues to Council's attention. In other words, Stan is tireless in his pursuit of fair play for conservation issues.

For all of these reasons and more, Stan Rosenbaum is a fitting recipient of the 2008 Conservation Award (Member).

### **Robert E. Lee — Mary Stuart Education Award**

The Mary Stuart Education Award was established to recognize members, non-members, or organizations for their outstanding achievements in the field of natural history education in the Ottawa Region.

Selecting a recipient for this year's Mary Stuart Education Award was not difficult, because he was not

far away. The award goes to our own Rob Lee, leader of the OFNC's junior branch—the Macoun Field Club—for the past 16 years. This award is not just for being the leader, certainly worthy of an award in itself, but for having such an extraordinary ability to teach natural history and to inspire young people. Rob is first

and foremost an innovative educator who for decades has shown members of the Macoun Field Club how to observe and learn for themselves, how to figure out what they are seeing, and how to be resourceful in their pursuit of knowledge. Rob and his students sometimes do extraordinary things. He recently had them dig through ant nests looking for (and finding!) a rare species of aphid. Why would he do this? Because Rob himself is curious about the ants and the aphid farming they do, and he shares this enthusiasm for learning and curiosity about the natural world with the Macoun Club members. We wonder whether the parents of the Macoun kids realize what a treasure has been made available to them through the Club. Rob encourages Macoun Club members to talk about their discoveries,

giving them priceless experience in speaking in front of a crowd, and he encourages them to write up their results for the Club's publication, *The Little Bear*, giving them experience in scientific writing. They participate in Rob's web page, giving them an opportunity to learn about the use of computers in sharing information and researching subjects. He leads them to appropriate books in the Macoun Club's own library, instilling a love of literature. The rich world of natural history that Rob introduces to his charges will always remain with them, no matter where their lives take them. Rob Lee is a teacher to be watched and to be emulated, and for this, the OFNC is very pleased to award him the 2008 Mary Stuart Education Award. Wouldn't Mary have been delighted!

### Otto Loesel — Anne Hanes Natural History Award

The Anne Hanes Natural History Award is given in recognition of a member who, through independent study or investigation, has made a worthwhile contribution to our knowledge, understanding, and appreciation of the natural history of the Ottawa Valley.

Otto Loesel is the recipient of this award for 2008, recognizing his years of independent study of wood-rotting fungi (Polyporales) in the National Capital Region and in particular in Gatineau Park. Otto has a long-standing passionate interest in nature and a love of learning and teaching about the polypore fungi, on which he is a self-taught expert.

Otto has spent a large amount of time exploring and inventorying the fungi (mycoflora) of Gatineau Park. Based on numerous field trips to different areas and habitats in the Park, he developed a list of 106 species of fungi. Significantly, Otto recorded specimens of an unusual polypore (wood-rotting fungus that grows on snags and fallen tree trunks) in the Ottawa region 11 times, and later at 39 locations in Gatineau Park and the National Capital Commission greenbelt, and one at Larose Forest. Otto checked with experts, and it became evident that this unusual polypore was *Trametes gibbosa*, a species commonly found in Europe and recently introduced in North America. Otto's specimens were the first recorded for Canada. Otto published an

article in the September 2008 volume of *Trail & Landscape* on his discovery of *Trametes gibbosa*.

Otto is keen to share his knowledge of fungi, and last year he took the Macoun Field Club on a mushroom identification foray to identify species such as bracket fungi and crust fungi. He has also led walks to see the polypores of Gatineau Park. His depth of knowledge of fungi was beautifully demonstrated at one of the Tuesday evening OFNC monthly meetings when the scheduled speaker couldn't make it. Otto volunteered to give an impromptu talk on fungi, and it was fascinating from beginning to end. Otto also gave generously of his time in order to give two informal workshops on polypores at the Fletcher Wildlife Garden at which participants brought photos of unidentified polypores, which he then helped them to identify and explained what they were. The workshops were tremendously interesting and an indication of how much Otto is willing to help anyone who shows a keen interest in learning more about polypores.

Otto is a member of the Mycologues amateurs de l'Outaouais (amateur mycologists), and he contributes photos of fungi to an Internet site. In 2006, he participated as a mushrooms (mycology) contributor to the 2006 BioBlitz in the Larose Forest.

We are delighted to present the Anne Hanes Natural History Award to Otto Loesel.



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